THE PSYCHOPHYSIOLOGICAL FUNCTION OF BLINKING

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PREFACE

Recently, there has been speculation, both psychological and physiological, as to the function of the human eyeblink. Specifically, it has been suggested that the eyeblink might serve an "eraser" or masking function in visual perception, as well as for visual imagery. It is the latter function of the human eyeblink to which the present thesis addresses itself.

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Blinking in organisms has been defined as a protective mechanism, involving movements of the upper and lower lid, resulting in their temporary (.13 to .20 sec.) closure (Duke-Elder, 1968; Hall, 1936). It has been noted (Duke-Elder, 1968; Blount, 1928; Ponder & Kennedy, 1927), that the frequency of blinking varies in accord with both the phylogenetic and ontogenetic development of organisms. Hence, animals below the vertebrates on the phylogenetic scale do not give evidence of blinking activity. Within the class vertebrates, the lower forms (aquatic vertebrates) do not exhibit blinking activity. In general, blinking appears to be characteristic of all vertebrates living in contact with air and possessing eyelids. Exceptions to this generalization appear to be that of some reptiles. Blount (1928) noted differences in the blinking activity of land animals, based upon whether they were the hunted (herbivora) or the hunters (carnivora). It was reported that the former class of land animals gave evidence of a mean blink rate in excess of five times that of the latter. Further, Blount (1928) also reported that the arboreal primates possessed blink rates as high as four times that of the herbivora. Thus, it seems that as one ascends the phylogenetic scale, the blink rate tends to increase. Ontogenetically, the blink rate appears to evolve, at least in humans, in a way similar to that of its phylogenetic development, e. g. increasing as one ascends the scale. Duke-Elder (1968) reported that blinking movements, save those of a reflexive nature, remain undeveloped in human infants until approximately age six months. Similarly, Hall (1945) reported that until binocular vision and fixation have extablished themselves in the human infant, the blink rate does not differ from that of the lower animals. In general, it appears that the blink rate increases with the phylogenetic and ontogenetic development, and this may implicate the eyeblink in an organism's ability to receive, encode and process visual information from its environment.

Additional information which would seem to implicate the eyeblink in the processing of visual information comes from the observations of Hall (1945) and Ponder and Kennedy (1927). It was noted that the human blink rate varied considerably, as a function of the activity that an individual was engaged in. Both Ponder and Kennedy (1927) and Hall (1945) reported immediate changes in blink rate when an individual changed his activity from conservation to reading, with the blink rate during conversation being eight times higher, on the average, than the blink rate for reading. Also, Ponder and Kennedy (1927) reported findings that would place some question on the importance of blinking for keeping the cornea moist. The blink rates of <u>S</u>s were observed in an arid environment and also in a humid environment. Presumably, if the blink serves to moisten the cornea, the blink rates in the two environments should differ, with the blink rate in an arid environment being higher. However no differences in blink rate were observed. Once again, such observations would seem to imply that the eyeblink may have some functional significance for the processing of visual information. Duke-Elder (1968) concluded that the function of blinking appears to be threefold: it serves a protective role, in that it moistens the cornea, keeping it free from dirt and debris; it promotes the drainage of tears; and it may tend to eliminate the blurring of images during actual movements of the eyes.

Several researchers (Mower, 1933; Jung, 1972; Yarbus, 1967; Blount, 1928; Barlow, 1964; Davson, 1963; Stephenson, 1966) have offered hypotheses as to the significance of the eyeblink, as it relates to visual perception. Mower (1933) found that eyemovements were accompanied by either partial or complete closures of the eyelids. Further observations indicated that, at least the more extensive saccadic movements and blinking occurred together. Mower (1933) offered two hypotheses to account for the above observations. The first, suggested that blinking occurs because it has been inhibited during the prior fixation. However, this suggestion is somewhat suspect when one considers the finding reported by Ponder and Kennedy (1927) that the impulse to blink may be abated by fixating on a new point. The second hypothesis offered by Mower (1933) as to the function of blinking is that it may serve to eliminate retinal images. A similar suggestion has been made by Blount (1928).

More recently, Jung (1972) has noted that saccadic eyemovements, besides serving the obvious function of visual goal fixation, may supply information about the onset of a "new" visual stimulus. That is, each saccade, in centering the fovea on a different part of a visual stimulus is, in a sense, producing a different visual stimulus. Also, it has been observed that pre-fixation saccades are accompanied by a blink (Jung, 1972; Yarbus, 1967). In light of this evidence, it has been suggested that each fixation period after a saccadic blink can be compared to stimulation by a "new" visual pattern at light onset. That is, it may be that neuronal discharge resulting from the fixation reflex may, in some way, provide a code which opens the visual pathways for information intake. Similarly, the sudden light decrement caused by a blink during normal information processing may be considered equivalent to a laboratory stimulus at light offset. That is, the neuronal impulses which prevent information intake through some inhibitory process in the visual pathways. Similarly, Yarbus (1967) has suggested that a saccade or a blink may result in the cessation of certain retinal impulses and the reestablishment of others, with the implication that such a state of affairs could serve to open or close the visual pathways to information intake. Finally, Barlow (1964) has suggested that off discharges, resulting from a saccadic blink may serve a role in "clearing the visual screen" of a retinal image, prior to a subsequent fixation and the formation of another retinal image.

Jung (1972) has pointed out that the cancellation of previous images does not imply that information about those images is forgotten. Rather, it is assumed that such information should be sufficiently coded, processed and stored before the image is destroyed. It would seem that once the information from an image has been coded, processing and storage of that information would be most efficiently accomplished during a time when the visual system is not capable of taking in additional information. Such a time, in light of the discussion thus far, may be during a saccadic blink and the subsequent saccade. Jung (1972) has concluded, that without cancellation of previous images and the properly timed onset of the new image, subsequent saccades might result in multiple representations of the visual surround. This, it is thought, would be experienced as something much like double vision.

Additionally, Davson (1963) and Stephenson (1966), in noting that movements of the eyes are accompanied by blinking, state that blinking may serve to aid the eyes in changing their fixation point. As Davson points out, lesions of the frontal motor center make the changing of the fixation point difficult, but that the change may be brought about by cutting off the visual stimulus through blinking the eyes. Therefore, it is possible, that in the normal individual, blinking is an aid, although not a necessary one, in inhibiting the fixation reflex, prior to the adoption of a new fixation point. These results are interesting in light of Jung's (1972) suggestion that a saccade alone may be responsible for the extinction of previous visual information. For even if this is the case, the relationship between blinking and fixation reported by Davson (1963) and Stephenson (1966) would still tie blinking, although indirectly, to the "clearing of the visual screen". Therefore, on the basis of the physiological theory discussed, it would seem reasonable to postulate some sort of "erasure" function for the eyeblink in the processing of visual information, from stimuli physically present in an individual's environment.

More recently, the results of several studies (Barron, 1973; Malstrom, 1973; Wegmann & Weber, 1973), have suggested a similar "erasure" function of the eyeblink for the processing of imagined visual information. Generally, the findings have been that individuals, characteristically, blink less during information processing in a visual imagery task than they do before or after the task. One might hypothesize that such findings indicate blinking, in some way, "breaks up" or "erases" the visual image. Additional support for the proposed "erasure" function of the human eyeblink, with respect to the processing of imagined visual information, comes from the observations of Leask, Haber and Haber (1969). It was reported that in questioning children possessing eidetic imagery, several individuals reported that they "controlled" or "eliminated" interferring images by blinking their eyes. However, an erasure function for blinking, with respect to visual imagery, would seem more plausible if similarities between ocular activities for visual perception and visual imagery tasks could be established, in that the arguments for an erasure hypothesis, thus far, have been in the context of visual perception.

Both Moore (1903) and Perky (1910) reported that the eyes of people imagining scenes with their eyes closed did not remain stationary. Jacobson (1932) reported that the activity of the extraocular muscles during an imagery task was similar to the activity of those muscles displayed during visual perception. Additionally, Totten (1935) concluded that the eyes followed the contours of the pattern that was being imagined. Lorens and Darrow (1962) found marked increases in eye movements during mental arithmetic, while Antrobus, Antrobus and Singer (1964) found increased eye movements in Ss asked to imagine moving events relative to static events. Deckert (1964) reported similarities in pursuit eye movements for Ss imagining and then actually watching a pendulum. However, subsequent studies (Brown, 1968; Lenox, Lange & Graham, 1970) failed to corroborate Deckert's (1964) findings.

Zikmund (1972) points out that these studies have too many methodological omissions for meaningful comparisons to be made. Zikmund (1972) concludes that there exists a certain similarity between the physiological processes underlying visual perception and those occurring while sensory experience of vivid visual imagery takes place. Further, evidence suggests that the oculomotor components of visual perception are reactivated during vivid visual imagery. Therefore, on the basis of the above evidence, it would seem reasonable to assume that the hypothesized erasure function of blinking, presented by Jung (1972), with respect to visual perception, is also plausible for visual imagery. With the possibility of the proposed erasure hypothesis established, at a theoretical level, it remains to examine the literature concerned with the human eyeblink.

A good number of the earliest researches with regard to blinking used reading as the task. As mentioned earlier, both Pondor and Kennedy (1927) and Hall (1945) observed substantial decreases in blink rate when individuals were engaged in a reading task as opposed to conversation. Additionally, Hall (1945) observed the places in the text where individuals blinked. Interestingly, results indicated that most often blinks occurred at punctuation marks and next most often at the turning of a page. This finding would seem to be in line with the notion that blinking may signal the end of a discrete thought process

(Yarbus, 1967), and make for a convenient point at which to "erase" the image and provide "dead time" for processing and storage of the information from the image. Also, Hall (1945) reported that those Ss classified as "good" readers tended to follow the blinking pattern described above more consistantly than did those Ss classified as "bad" readers. In fact, a substantial number of the "bad" readers gave no evidence of blinking at all, during the reading task. From an erasure point of view, this suggests that subsequent images might interfere with previous ones as well as pointing to the idea of blinking providing "dead time" to be used for processing and storage of information.

The studies to be reviewed next attempted to relate changes in blink rate to attentional changes in the individual. It was generally thought that blink rate was inversely related to attention. Luckeish (1940) reported that blinking increased when Ss wore lenses which caused a blurring of retinal images. It would seem difficult to interpret this finding in terms of an attentional position, in that it appears that such a position would expect a decrease in blinking with blurred images. That is, extracting information from a blurred image would seem to be a more difficult task than extraction of information from a "normal" retinal image and would require a greater degree of attention on the part of the individual. Poulton and Gregory (1952) observed the blink rate of Ss engaged in a visual tracking task. The findings were that the blink rate was elevated before and after, but supressed during the task. These findings are similar to the findings of more recent studies involving imagery tasks (Malstrom, 1973; Wegmann & Weber, 1973). Additionally, Poulton and Gregory (1952) manipulated the blink activity of the Ss. In one manipulation, Ss were instructed to blink voluntarily while engaged in the task. The second manipulation involved occluding the display from the Ss for short periods. Both manipulations resulted in decreased performance on the tracking task. Poulton and Gregory (1952) suggested that the observed changes in blink rate were due to fluctuations of attention. However, it could be assumed that the decreased performance observed was due to the fact that the voluntary and simulated blinking was ill timed. As Jung (1972) has stated, the timing of saccades and saccadic blinks is crucial to insure proper encoding, processing and storage of information from a retinal image. Still, the findings of Poulton and Gregory (1952) seem reasonable from an attentional point of view. It could be argued that forcing a subject to blink, or occluding the display from him was distracting and resulted in attentional fluctuations. Drew (1951), in examining the effect of a visual motor task upon the blink rate, found that, for all Ss, the blink rate varied inversely with the difficulty of the task. Further, it was observed that, when the speed and difficulty of the of the task were varied, blinking occurred before and after, while being suppressed during the difficult task periods. Gregory (1952) investigated changes in blink rate during and between three "non-visual" tasks. It was observed that the blink rate fell below its resting rate during each task and increased above resting rate between each task. If the tasks were truly non-visual, the above results would be detrimental to an erasure hypothesis. However, at least two of the tasks, stylus maze and mental multiplication, would appear to have had some imagined visual components. If this is the case, then the results are consistant with previously reported findings (Malstrom, 1973; Wegmann & Weber, 1973) and appear to be just as interpretable in terms of an erasure hypothesis as they are in terms of an attentional hypothesis. Finally, Glaser and Kennard (1962), using a visual detection task, reported that reduction of blink rate is related to increases of attention. The studies reported above have sought to relate the human eyeblink to attentional changes in the organism. However, it would seem that a good deal of the findings are as interpretable in terms of an erasure hypothesis as they are in terms of an attentional position.

The findings of several other studies would seem to go against a position relating blinking to attentional changes. Wood and Bitterman (1950), using Tinker's (1945) speed reading test, found the blink rate was lower for slow as opposed to fast processing of written material. It would appear that attentional demands should increase as the speed of processing increases and from an attentional point of view, the prediction would be that the blink rate should decrease. The findings of Wood and Bitterman (1950) however, would appear to make sense in terms of an erasure hypothesis. Recall that Hall (1945) reported that "good" readers tended to blink most often at the occurrences of punctuation marks in a line of print. It was suggested that this pattern of blinking might provide an individual with a relatively meaningful "chunk" of information to encode, with the "dead time" provided by the subsequent saccade and blink allowing for efficient processing and storage of that bit of information. Therefore, as the speed of processing increases, and bits of information are taken in more rapidly, it would be expected that the blink rate would increase. Sidowski and Nuthmann (1961) found that blinks decreased with trials of a verbal learning task. Again, it would seem that as learning proceeds, the attentional requirements for _S_s would decrease. Under such conditions, it would seem that an attentional position would then predict an increase in blinking rather than the observed decrease. Clites (1935) also has presented data which appear problematic, both for an attentional as well as for an erasure hypothesis. Using three water dipping problems, it was observed that Ss who successfully solved the problems blinked more rapidly during the presentation of the problems than during subsequent solution periods. Those Ss who failed to solve the problems showed no difference in blink rate for the presentation versus the solution periods. In accord with an attentional approach, it would seem that the blink rate should remain relatively constant from presentation through solution. This would seem plausible, in that, Ss would have to attend to both the presentation as well as the solution of the problem. Further, observations by Clites (1935) indicated that blinking decreased for weight lifting and weight checking tasks, while increasing for saying the alphabet forward or bachward, and for mental multiplication. These latter results appear detrimental to an erasure hypothesis. Last, Baumstimler and Parrot (1971) investigated the effect of the execution of a motor response upon blinking. It was found that blinking was inhibited until the response had been completed. The task required the Ss to monitor the response apparatus without looking at it. Therefore, it seems tenable that the inhibition of blinking could have been due to the S's having to imaginally reconstruct the response apparatus, and maintaining that reconstruction until the response was executed.

The last group of studies to be reviewed will be those that investigated the effects of various imagery tasks on the eyeblink activity of individuals. Antrobus, Antrobus and Singer (1964) carried out an investigation of the effect of different forms of mentation upon eye movement and blinking activity in individuals. It was found that the blink rate was twice as high for active thinking as for passive thought. Additionally, blinking was significantly greater for the active thinking periods, relative to wish supression episodes. With respect to visual imagery instructions, it was observed that both eye movement and blinking were significantly greater for active versus static scenes. It was suggested that the observed differences in eye movement and blinking may have been related to cognitive change, but that such changes may have reflected emotional arousal. Holland and Tarlow (1972) investigated changes in blink rate as a function of memory load. In the first study, _S_s were shown digit strings and asked to remember them, using visual imagery, for later recall. It was found that blinking was greater preceeding incorrect versus correct responses. The latter finding suggests that incorrect responses were possibly due to the increased blinking which eliminated a _S_'s visual image of a digit string. In the second study (Holland & Tarlow, 1972) which used a mental addition task, it was again observed that incorrect responses were preceeded by more blinking activity than were correct responses. Holland and Tarlow interpreted their findings as indicating that blinking, in some fashion, is disruptive of, at least some cognitive processes. Holland and Tarlow do not, however, specify or hypothesize as to the nature of such disruption. Some recent studies however, have made attempts to specify the disruptive nature of blinking upon certain forms of cognition. Malmstrom (1973) observed the blinking activity of individuals under perceptual and imagery presentation conditions for spatial, non-spatial, and directional problems. Under all treatment combinations it was found that blinking was suppressed during stimulus presentation and response intervals, with burats of blinks occurring in the following recovery interval. It was suggested that the eyeblink may serve the function of an "eraser". Barron (1973) also employed a visual imagery task, and found that the blink rate was suppressed during task intervals relative to pre- and post-task intervals. Finally, Wegmann & Weber (1973), using an imagery task, observed that the blink rate was suppressed during the task period relative to the pre- and post-task periods. Also, as with the findings of Barron (1973), it was found (Wegmann & Weber, 1973) that the post-task blink was higher than the blink rate during the pre-task period. It was hypothesized that blinking may serve an "erasure" function in the processing of imagined visual information. It was also observed (Wegmann & Weber, 1973) that as the amount of information to be processed increased, or as the spatial representation of the information became more complex, performance decreased.

It would seem that in view of the theoretical and empirical evidence presented, a study investigating the hypothesis that blinking may serve an erasure function for the processing of imagined visual information, would be a reasonable one. Much of the existing empirical data, it seems, could fit an erasure interpretation. To date however, the results of studies cited in this introduction have only been suggestive of such an interpretation, in addition to being amenable to a position relating the eyeblink to the process of attention. The reason that the specific effect of the eyeblink, with respect to visual information processing, has not been resolved seems due to the fact that, to date, it has been used as a dependent variable. Such a situation only allows one to note that fluctuations in blinking do, in fact, occur with changes in the activity that a person is engaged in, but do not allow one to investigate the specific nature of the observed changes. Therefore, the present study used the eyeblink as an independent variable, in an attempt to specify the role which the eyeblink plays in the processing of imagined visual information.

The present study examined the erasure hypothesis by experimentally manipulating an individual's blink activity either prior to an imagery task or during the task. With respect to the first manipulation, it has been noted (Wegmann & Weber, 1973) that _S_s tended to blink more often as the beginning of a trial approached. This was interpreted as indicating that _S_s may have been attempting to clear their "visual screens" just prior to the beginning of the trial. Assuming the interpretation is valid, it is predicted that, preventing a S from blinking just prior to the beginning of a trial should result in poorer performance, in that the S would not have the opportunity to rid his visual system of extraneous visual information, prior to the trial. Secondly, it is hypothesized that, performance should decrease if an S is required to blink while attempting to perform an imagery task, in that blinking during the task would result in the breaking up of the images that the S was attempting to form. Lastly, it is hypothesized that performance on the imagery task would decrease as the amount of material to be processed increases and as the complexity of the spatial representation of that material increases.

Method

Subjects

The Ss for the present experiment consisted of 80 undergraduate volunteers, 40 males and 40 females. All were enrolled in an introductory general psychology or introductory experimental psychology course at Oklahoma State University. All participants received course credit for their participation in the study. Those Ss who wore eyeglasses or contact lenses were asked to remove them prior to participating in the study. Fourteen potential Ss were dropped from further participation, after the practice trials, due to their inability to perform the task.

Apparatus

The eyeblinks of each S in the present study were measured by means of an eye movement monitor (Biometrics, Inc., model SGH/V-2). Blinks were recorded on grid line chart paper, using a 10 speed chart mover, model 485 (Harvard Apparatus Co., Inc., special product 2045), in conjunction with a Harvard Apparatus recorder, model 350 (Harvard Apparatus Co., Inc.). Events for each trial were manually recorded by the E, on the grid line chart paper. For this, a Harvard Apparatus Event/Time Marker Module, model 283 (Harvard Apparatus Co., Inc.) in conjunction with an Electro Snap microswitch, model E4-3, was used. Additionally, all Ss were asked to place their chins into a chin rest (Biometric, Inc., model 115) at the beginning of each trial. A large sheet of white construction paper was attached to the frame of the chin rest so as to provide a ganzfeld in the front and lateral visual fields of the Ss to eliminate distractions and prevent the use of physical objects as matrices.

Procedure and Materials

The Ss were informed that they would be required to imagine a number being traced out in a three by three matrix, each cell of which had been given a name (Fig. 1a.). To trace out a letter, a S was presented with a series of cell names of the matrix, and asked to imagine drawing a line from the center of one cell to the center of the next cell he heard called out, until the sequence of cell names had ended (Fig.1b.). In all cases, letters were traced out such that, a given move was to a cell adjacent to the one moved from. That is, in all cases, the sequence of cell moves was such that, the required visualization process would approximate the required spatial properties of the letters, were they to be actually written on a piece of paper.

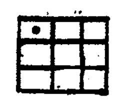
To accustom the Ss to the task, each received eight practice trials, without any concurrent activity required. The stimuli for these eight practice trials consisted of the digits 1 through 9. Initially, the task was explained to the Ss (Appendix A) and they were provided a sheet with a printed matrix on it, with the cells of the matrix labelled (Appendix B). They were then allowed to study the matrix until they were confident that they could identify the spatial location of a cell given only its name.

UPPER LEFT	TWELVE O'CLOCK	UPPER RIGHT
NINE O'CLOCK	CENTER	THREE O'CLOCK
LOWER LEFT	SIX O'CLOCK	LOWER RIGHT

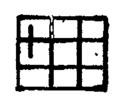
Fig. 1a. 3X3 matrix with associated cell labels

<u>S</u> heard — <u>S</u> was to imagine

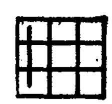
1. "UPPER LEFT"



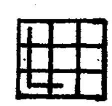
2. "NINE O'CLOCK"



3. "LOWER LEFT"



4. "SIX O'CLOCK"



5. "LOWER RIGHT"

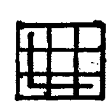


Fig. 1b. Example of an experimental message and its imaginal counterpart

Following this, the S was provided with a sheet illustrating how each number would look, if traced out in the matrix using a series of cell names (Appendix E). To insure that the S attended to the sheet of numbers, he was required to call out the cell names that each number occupied, in the order indicated on the sheet. Further, the E informed the S that if a number was traced out, it would be done using the sequence of cell names indicated on the sheet, for that number. The S was then instructed to place his finger on the first cell that was called out over the tape, and to continue tracing from cell to cell, with his finger, as the remaining cells were called out. At the conclusion of the sequence, the S was asked to respond by calling out the number that had been traced out. Following this, the sheet of numbers placed in the matrix was returned to the S, with the instruction to look at the number 5, noting the cells of the matrix it occupied. The E then took the sheet back from the S and told him to trace out the number 5 by calling out the appropriate cell names, starting at the 12 o'clock position.

Next, the S was given a diagram illustrating the sequence of events for each of the eight practice trials (Appendix F). The S was told that there would be a "ready" called out over the tape, to signal the beginning of a trial. This was followed by a blank interval of variable length such that it was of the same duration of time as would expire between the beginning and the end of the sequence of cells. Following the variable interval, the first cell of the sequence was called out. This was followed by a two sec. delay, and S was informed that he was expected to form an image of the matrix and the starting cell of the sequence, in the two sec. delay period. The S was then told that, following the two sec. delay, the remaining cells of the sequence would be called out at a rate of two per sec.. Once the sequence was finished, its end would be signalled by the word "start" called out over the tape. Each S was informed that the occurrence of "start" signaled the end of the sequence, as well as the beginning of the response period. The S was then told that following "start" he would hear "one", "two", "stop", called out over the tape (an interval of three sec.), with "stop" signalling the end of a trial. The S was told to respond at any time between "start" and "stop". This would be followed by a delay of 20 sec. until the beginning of the next trial.

Additionally, Ss were told to sit forward, placing their chin in the chin rest, remaining in that position until they heard "stop" at the end of the trial. At that time, Ss were instructed to sit back and relax, until they heard the next ready. Also, Ss were told to sit with their hands folded together throughout the experiment and to keep their head motionless, while in the chin rest. These instructions were intended to prevent any tactual or kinesthetic processing of the verbal messages. At the conclusion of the initial eight practice trials, Ss who had not obtained at least three of the eight numbers correct were excused from participation in the remainder of the experiment.

Following the initial eight practice trials, each S then underwent another series of four practice trials. The stimuli were again numbers, but the S was required to engage in the concurrent activity to which he had been randomly assigned (blink, tap, suppress, no instruction) at the locus of the trial to which he had also been randomly assigned (pre-task or during the task). The Ss were instructed to tap or blink in time with the reading of the cell sequence, two blinks or taps per sec.. To illustrate the addition of the concurrent activity and its locus in the trial, the S was shown one of two trial diagrams, in accord with his specific condition assignment (Appendices G and H).

At the conclusion of the practice trials, Ss were told that the procedures for the remainder of the trials would be identical to that of the last four practice trials, with the exception that the cell sequences would trace out block capital letters, rather than numbers. Numbers were used in the practice trials to insure that all subjects would be equal, in terms of letter familiarity at the beginning of the experimental trials. The S was then provided with a sheet illustrating how the letters of the alphabet would look if traced out in the matrix

(Appendix I). Once again, to insure that the S studied the sheet, he was required to call out the names of the cells occupied by each letter, in the order indicated on the sheet. Once this was done, the experimental trials began.

Not all letters of the alphabet were utilized in the present study. Initially, the number of cell moves needed to trace out each letter in the matrix, in block form, was ascertained. Secondly, it was determined which of the letters of the alphabet were overlapping and which were non-overlapping. An overlapping letter was defined to be a letter, when being traced out, that required the S to imagine going back over an already imagined line, or crossing an already imagined line. Following the determination of the above letter characteristics, 12 letters of the alphabet were selected for use in the present study. Of the 12 selected, six of the letters took eight cell moves to trace out. These six letters were defined to be long letters. Of the six long letters, three had the property of being overlapping (E, H, I), with the remaining three being defined as non-overlapping (G, O, S). Of the remaining six letters selected for use, two took four cell moves (Y, L), two took five cell moves (T, J), and two took six cell moves (X, U). This latter group of letters was defined as the short group. For this group, one of the two letters in each of the three pairs comprising the group was an overlapping letter (Y, T, X), with the remaining letters of the group being defined as non-overlapping (L, J, U). Each of the selected letters was presented to the Ss twice, via a tape recorder and headphones, the order of presentation being randomly determined.

Results

Prior to the analysis of the data from the experimental trials, the practice data was analyzed. The data were analyzed as a completely randomized design (Kirk, 1968, p. 104) with groups as the main factor, with eight levels. The data were expressed in terms of percentage correct and therefore an arc sine transformation was performed on the data prior to the analysis. The analysis of the practice data is summarized in Table 1. Examination of Table 1 shows that the eight groups did not differ significantly, $F(7,72) = 1.278$, $\underline{p} < .27$, with respect to performance on the imagery task, without concurrent activity.

Following the analysis of the practice data, the data collected in the experimental trials was analyzed, using a SPF pq . rv (Kirk, 1968, p. 311) design (4X2X2X2). The between factors were concurrent activity (blinking, tapping, suppression, or no instruction) and locus of activity (prior to the beginning of a message or during a message). The within factors were message length (long-eight steps versus short-four, five, or six steps) and complexity (overlapping versus non-overlapping messages). Once again, an arc sine transformation was performed on the data (percentage correct score) prior to the analysis. The analysis of the data from the experimental trials is summarized in Table 2 and graphically presented in Figure 2. Examination of Table 2 shows that message length was a significant factor, $F(1,72) = 40.078$, $\underline{p} < .0001$. Corre-

Table 1

AOV for practice trials performance data

Source	df	SS	MS	F
Groups	7	2.0175	0.2882	1.2781
Error	72	16.2358	0.2254	
Total	79	18.2534	0.2310	

Table 2

AOV for experimental trials performance data

Source	df	SS	MS	F
Concurrent Activity (A)	3	3.6754	1.2251	1.2721
Activity Locus (D)	1	1.4862	1.4862	1.5432
A*D	3	0.6907	0.2302	0.2390
Error a	72	69.3397	0.9630	
Length (B)	1	11.5539	11.5339	40.0789*
A*B	3	1.6419	0.5473	1.8985
D*B	1	0.0000	0.0000	0.0000
A*D*B	3	0.4724	0.1574	0.5463
Error b	72	20.7560	0.2882	
Complexity (C)	1	0.2422	0.2422	0.6829
A*C	3	0.3871	0.1290	0.3637
D*C	1	0.0070	0.0070	0.0197
A*D*C	3	0.0455	0.0151	0.0427
Error c	72	25.5433	0.3547	
B*C	1	6.5701	6.5701	23.2486*
A*B*C	3	0.7084	0.2361	0.8356
D*B*C	1	0.0328	0.0328	0.1161
A*D*B*C	3	1.8977	0.6325	2.2383
Error d	72	20.3476	0.2826	
Total	319	165.3987	0.5184	

* $p < .0001$

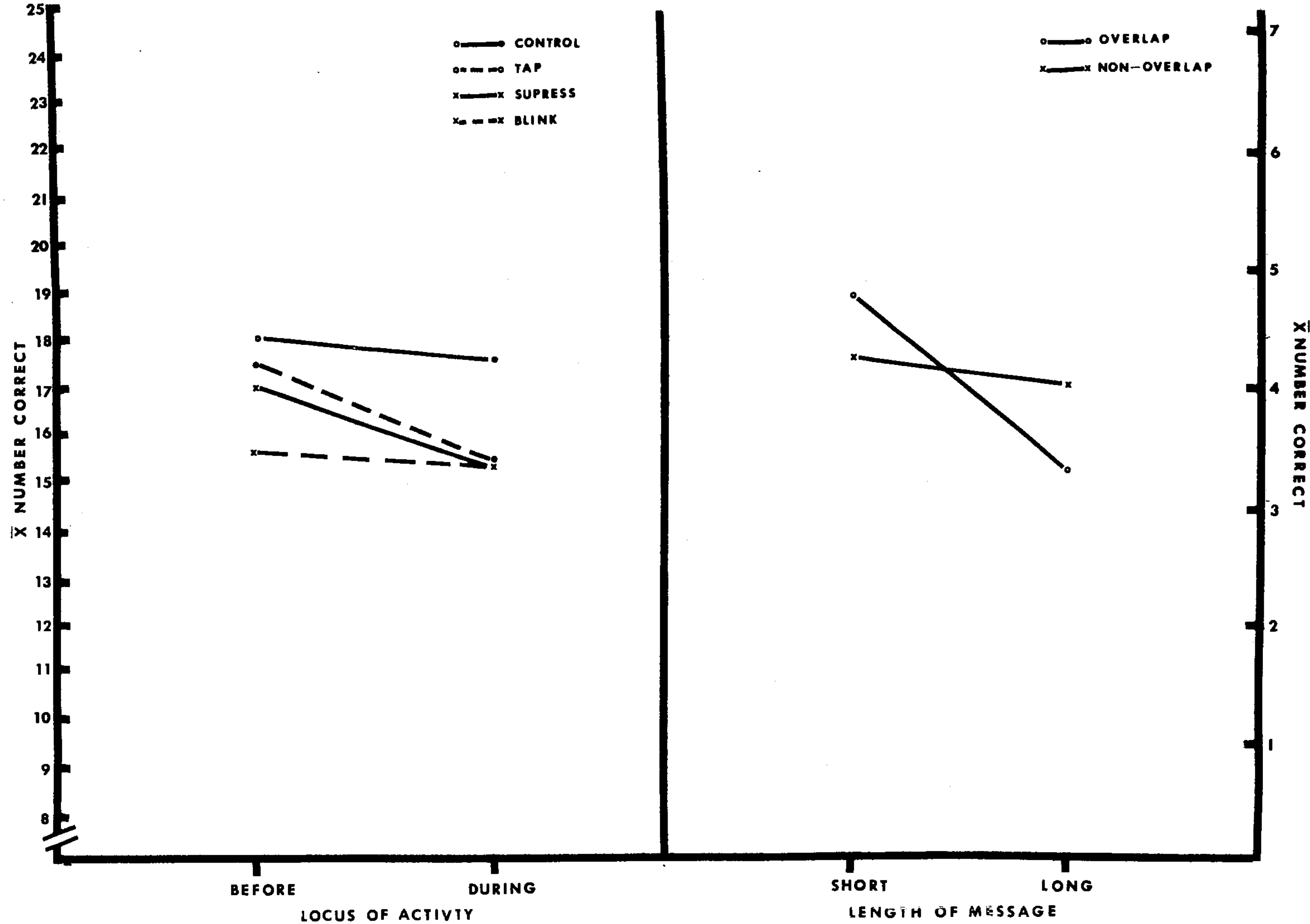


FIG. 2 PERFORMANCE DATA FOR GROUPS AND LETTERS

spondingly, Figure 2 shows that the mean number of short messages correct was 4.57, as opposed to a mean of 3.71 long messages correct. Also, inspection of Table 2 reveals that the length by complexity interaction was significant, $F(1,72) = 23.248$, $p < .0001$. Accordingly, a simple effects analysis for the factors length and complexity was carried out. The results of the analysis are summarized in Table 3. From inspection of Table 3, it can be seen that there was not a significant effect of length for non-overlapping messages, $F(1,72) = 1.398$, $p < .10$. The mean number of short, non-overlapping messages correct was 4.30, as opposed to 4.06 for long, non-overlapping messages correct. There was, however, a significant effect of length for overlapping messages, $F(1,72) = 62.271$, $p < .01$. Here, the mean number of messages correct was 4.85 and 3.35 for the short, overlapping and long, overlapping messages, respectively. Also, the effect of complexity was significant for both long and short messages. It was found that short overlapping messages ($\bar{X} = 4.85$) were significantly easier to process than short non-overlapping messages ($\bar{X} = 4.30$), $F(1,72) = 6.729$, $p < .05$. Further, long non-overlapping messages were easier to process ($\bar{X} = 4.06$) than were long overlapping messages ($\bar{X} = 3.35$), $F(1,72) = 14.647$, $p < .01$.

Next, the eyeblink data collected from the no instruction groups was analyzed. Prior to the analysis, the average blink rate was determined for each <u>S</u> for the

Table 3

Simple effects analysis for the length by complexity interaction

Source	df	SS	MS	F
Length for non-overlapping messages	1	0.3993	0.3993	1.3989
Length for overlapping messages	1	17.7747	17.7747	62.2709**
Error	72		0.2854	
Complexity for short messages	1	4.6679	4.6679	6.7292*
Complexity for long messages	1	4.6679	4.6679	14.6473**
Error	72		0.3186	

* $p < .05$

** $p < .01$

pre-task, task, and post-task periods. Figure 3 depicts the mean blink rate for the no instruction groups. Inspection of Figure 3 clearly shows that the blink rate during the imagery task was considerably lower ($\bar{X} = 2.486$) than the blink rate for the pre-task period ($\bar{X} = 9.012$) or the post-task period ($\bar{X} = 9.049$). The eyeblink data was analyzed as a single factor, randomized block design Kirk, 1968, p. 131), with the factor, period, having three levels (pre-task, task, post-task). The analysis is summarized in Table 4. In looking at Table 4, it can be seen that the blink rates across the three periods differed significantly. In light of the significant period factor, planned, non-orthogonal, pair-wise comparisons (Dunn's procedure; Kirk, 1968, p. 79) were made. The multiple comparison indicated that the mean blink rates for the pre- and post-task periods differed significantly from the mean blink rate during the task period, but not from one another, $d = 6.525$, $\bar{X}_{pre} - \bar{X}_{task} = 6.526$, $\bar{X}_{post} - \bar{X}_{task} = 6.563$, $\bar{X}_{pre} - \bar{X}_{post} = .037$. The results of the multiple comparisons are summarized in Table 5.

A composite confusion matrix for all presentation groups was prepared and appears as Table 6. The columns of Table 6 represent the letters actually traced out, while the rows of the table correspond to the response given by the Ss. Please note, the most frequent error for each letter is starred. Inspection of Table 6 shows that the most prevelant errors, for any given letter, shared

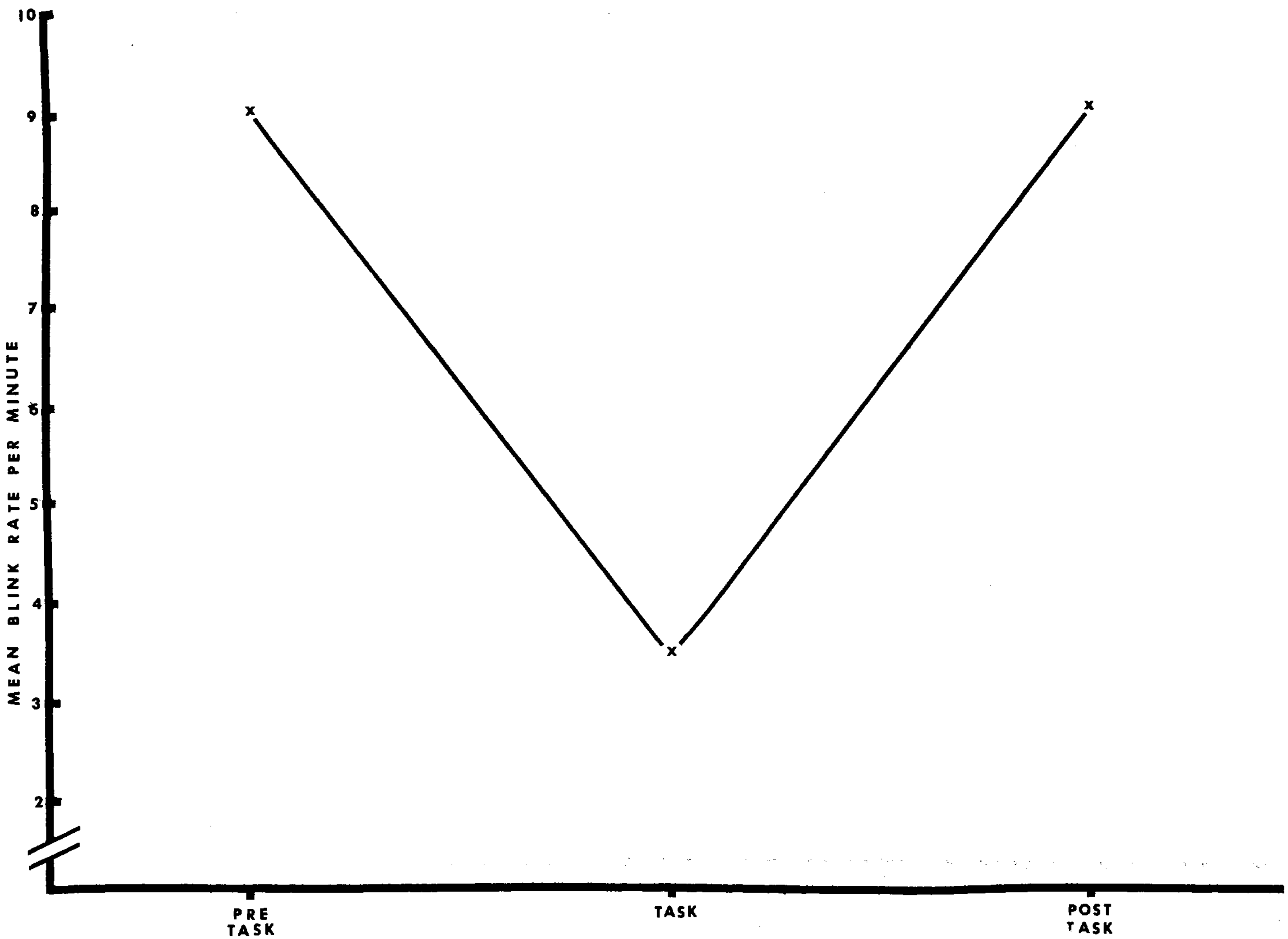


FIG. 3 CONTROL GROUP BLINK RATES FOR PRE, TASK, AND POST TASK

Table 4

AOV for control Ss blink rates for pre-, task, and post-task periods

Source	df	SS	MS	F
Subjects	19	1379.4072	72.6003	
Periods	2	571.1300	285.5650	27.4915****
Residual	38	394.7199	10.3873	
Total	59	2345.2572	39.7501	

**** $p < .0001$

Table 5

Multiple comparisons of blink rates during pre-, task, and post-task periods

	$\bar{X}_{task}$	$\bar{X}_{post-task}$	$\bar{X}_{pre-task}$
$\bar{X}_{task}$		6.562*	6.526*
$\bar{X}_{post-task}$			0.037
$\bar{X}_{pre-task}$			

d = 6.525 * $p < .05$

Table 6

Composite confusion matrix for $\underline{S}$s responses

INPUT

OUTPUT	J	L	U	T	X	Y	O	S	G	H	E	I
A	1		1					1				1
B	1						3	3	4	2	2	1
C	4	3	4				6	2	5*	1	9	4
D	4		1						1		1	
E	1		1					6*	1	6	74	4
F			1	1					1			
G	2	2	6				12*	2	115	2	5	2
H	1		1	1		1	2	1	1	105	1	
I		4*									1	95
J	107	4	4	1			1	3	3		1	2
K	2				6*	1	2	1		9*		2
L	5	132	7			2			1		1	
M		1	1			1				2	2	
N		1			1		1	1	1	4		2
O	1		8*				97		5*			1
P			1			1	1	2		2	1	1
Q												
R								1	1	2		
S				1			4	111	4	2	31*	2
T				134		10*	3	1	1	2		19
U	15*	1	106		1		8			2		
V		1	1		1	6					1	
W	2	1	5		1		2	2		2	1	2
X				1	135	4	1		1	2	2	3
Y		1		5*	6	120	1	1		2	2	5
Z	2		1	5	2		1	1	1		1	6
-	11	10	10	11	7	14	15	21	13	13	24	9

spatial properties with the letter actually given (e.g., U for J, T for Y).

Following the end of each experimental session, each S was asked whether or not the concurrent activity they had been asked to engage in aided or hindered their ability to perform the imagery task. If an S answered in the affirmative, he was then asked to elucidate on the nature of the effect of the concurrent activity. While, overall, the results of the questioning did not yield any consistant results, some of the S's comments are interesting and suggestive. Specifically, two of the Ss in the suppress during condition, stated that they had forgotten about the instruction to suppress their blinking during the task. However, examination of their blinking protocols indicated that they had not blinked during the task, during the experimental trials. Further, a S in the blink during condition claimed that luminance changes created by blinking broke up her visual images. Lastly, several Ss in the blink before condition said that blinking prior to the start of the message helped to "clear the mind".

However, due to a question of the appropriateness of the analysis presented in table 2, given the pattern of randomization used in the present study, an alternative analysis has been suggested. In contrast to using four error terms as outlined in Kirk (1968), it was thought a more appropriate procedure might have been to pool errors b, c, and d and use the pooled error in their place.

Discussion

While the main hypotheses of the present study (effect of concurrent activity and locus of activity on imagery) were not supported, the pattern of results is quite consistant with that reported in an earlier study (Wegmann & Weber, 1973). It was found that length was a significant factor, along with the first order length by complexity interaction. Further, the results of the simple effects analysis was also consistant with those findings reported by Wegmann and Weber (1973), in that length was not a significant factor for non-overlapping messages, but was a significant factor for overlapping messages. The one finding of the present study, however, what was not found previously, was that complexity was a significant factor for both long and short messages. While the differences, with respect to complexity, were in the same direction in the present study and the earlier one (Wegmann & Weber, 1973), the earlier study had found no significant effect of complexity for either long or short messages.

The finding that short overlapping letters tended to be easier to process than short non-overlapping letters, is at odds with the predicted results. However, a possible explanation for the unexpected result comes from the work of Garner (1970), in which an attempt was made to determine what differentiates a good pattern from a bad pattern. It was concluded that good patterns are those patterns which, because of their uniqueness, offer few alternatives, when only partial information is given. Garner's (1970) conclusions seem to hold for the letters used in the present study. It was found that, given only a partial sequence of cell moves (the first or last three) for a letter, that the mean number of possible letters that could be formed from short non-overlapping letters was 7.7 versus 5.8 possible letters that could be formed from partial sequences of short overlapping letters. The average number of letters that could be formed from the first or last three moves of a given class of letters was calculated in the following manner. For each letter in a given class the imaginal counterparts for the partial sequence was determined and all the letters of the alphabet which had such a configuration were totaled. The totals for each letter in the class were then add together and the mean for the letters in the class was calculated by dividing the sum by the number of letters in that class. Therefore, it seems that short overlapping letters are more distinctive, and hence should be easier to identify. Similarly, the mean number of possible letters, given a partial sequence, for the long overlapping and long non-overlapping letters was 11.5 and 7.8 respectively. Hence, long overlapping letters should be harder to identify than long non-overlapping letters. The results of the present study are consistant with the above predictions, based on Garner's work.

Finally, the finding that the blink rate during the imagery task is significantly suppressed, relative to the pre- and post-task blink rate is consistant with the findings of previous studies (Holland & Tarlow, 1972; Wegmann & Weber, 1973). The finding that the blink rate is systematically altered with respect to the information processing activities of the learner, suggests some connection between information process and blinking. It was the purpose of the present study to examine the specific nature of that relationship.

More explicitly, it was suggested that the human eyeblink might serve an "erasure" function for the processing of imagined visual information. That is, the elevated blink rate prior to the beginning of a trial may serve the purpose of clearing the visual registers prior to information intake, while the suppression of the blink rate during the task may allow the S to retain and operate upon that information. Then, increased blinking following the trial may serve to rid the visual system of the no longer needed information. Such an interpretation does not appear viable, in light of the results of the present study. This is not to say, however, that blinking and information processing are unrelated. As has been alluded to earlier, it could be that blinking could be reflective of attentional fluctuations which may take place in the course of information processing. Along these lines, Kahneman (1973) has suggested that blinks may reflect changes in mental content (e.g. internal versus external orientation).

One other possibility remains which could explain the failure of the present study. It is entirely possible that the methodology employed was not sensitive enough to pick up the hypothesized differences. Surely, the cancellation and timing mechanisms (Jung, 1972) discussed in the introduction to the present study must take place very rapidly. Hence, the three second response interval allowed the Ss in the present study may have afforded them more than enough time to regenerate a clear image of a letter on which to base their response. Therefore, it is suggested that, rather than using a measure such as number of letters correct, it might be better to use a response latency measure.

Also, the procedures employed in the present study did not allow for precise monitoring of a subject's blinking behavior. There is some question as to whether the magnitude of the pen deflection of the recording equipment used was indicative of the amount of lid closure or of the time course of lid closure. Hence, it is conceivable that Ss may not have closed their lids fully, even though instructed to do so. Along these lines, it is interesting to note that the blinking protocols of several Ss changed during the course of the experiment, in the direction of decreased pen deflections. It is tempting to hypothesize that the changes noted in the blink protocols indicates that Ss were "fighting" a tendency not to blink.

However, the changes noted could have also been caused by slippage of the eyeglass frames upon which the infrared beam mechanisms were mounted. All in all, it would seem to be preferable to use a video tape recorder to record blinks. The present author has used such a system in the past, and it has proven quite reliable, while eliminating some of the more subjective aspects of scoring the blink protocols.

One last observation is that, introspectively, the light to dark transition created by blinking the eyes is crucial to the effect of blinking on performance of an imagery task. The author has noticed that, while the ability to visually imagine seems impaired by blinking at a rate compatible to the rate of blinking required of Ss in the present study, the impairment seems more pronounced if the blink rate is slowed, making the light to dark transition more pronounced. These observations are in line with the theorizing of Yarbus (1967) with respect to the function of blinking in visual perception. Hence, it might be a profitable undertaking to investigate the effects of different rates of blinking upon performance of a visual imagery task.

One other possibility exists which may serve to explain the failure to confirm the hypotheses of the present study. It will be recalled that the physiological theory which proposed a cancellation function for the eyeblink was concerned with involuntary blinking. However, the present study was concerned with voluntary blinking. While the musculature for the two types of blinks appears to be the same, it could be that each type of blink gives rise to distinctly different patterns of neuronal firing. Hence, while the neuronal patterning of an involuntary blink might serve a cancellation function, it could well be the case that those neuronal patterns initiated by a voluntary blink may not serve a cancellation function.

The close examination of the methodology of the present study seems warranted, in as much as there is no established literature focusing directly on the problem that was investigated in the present study. The fact that there does exist some published material, which is, at worst, suggestive of the hypotheses advanced herein, along with compatible theorizing from a different field (physiology) would seem to give the hypotheses advanced in the present study a certain degree of plausibility. Hence, maybe it is not the hypotheses which should be discarded, but rather what is needed is a careful examination and alternation of the methodology employed.

Summary

The fact that past research (Holland & Tarlow, 1972; Wegmann & Weber, 1973) had been suggestive of some functional connection between the processing of information and the human eyeblink, provided the impetus for the present study. More specifically, the present study focused attention on the eyeblink as an "erasure" mechanism, in the processing of imagined visual information. Secondarily, the study sought to examine possible stimulus characteristics which might affect performance in an imagery task.

Subjects were required to imagine tracing out a block capital letter in a three by three matrix, given a sequence of cell names. In addition, _S_s were required to engage in one of four types of concurrent activity (blinking, finger tapping, suppression of blinking, or no instruction), either prior to, or during the trial. It was predicted that blinking before a trial should enhance performance, while blinking during a trial should degrade it. The predictions for suppression of blinking were exactly opposite to those for the blinking activity. Finger tapping, it was predicted, should have little effect on performance, irrespective of its locus. With regard to the stimulus characteristics investigated, it was thought that both short and non-overlapping letters should be easier to process than long and overlapping letters.

The results did not confirm the hypotheses advanced, with respect to concurrent activity, or locus of that

activity. However, it was found that long overlapping messages were more difficult to process than short overlapping messages. Further, it was found that short overlapping messages were easier to process than short non-overlapping messages and that, with regard to long messages, the overlapping messages were more difficult to process. The former result is opposite of the prediction, and appears due to the uniqueness of the short overlapping letters used. Finally, the analysis of the control groups blink records indicated that the blink rate during the task was significantly lower than before or after the task.

Based on the results of the present study, it must be concluded that the evidence does not point to the eyeblink as an eraser. However, it was pointed out that failure to confirm the hypotheses advanced, could have been due to methodological difficulty and suggestions were offered to remedy the difficulties.

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APPENDIX A

INSTRUCTIONS TO Ss IN THE EXPERIMENT

This study concerns your ability to visually imagine The experiment is, in no way, a test of your IQ or personality. You will be required to imagine a checkerboard matrix such as the one on the sheet I have given you (Appendix B). Notice that the matrix has three rows and three columns. Also, notice that each cell of the matrix has a name. Note that the corner cells of the matrix are appropriately labelled up and down, right or left, and the center cell is simply labelled center. The remaining cells of the matrix are then labelled in a fashion similar to that of a clock (12 o'clock, 3 o'clock, 6 o'clock and 9 o'clock). It is essential that, after studying the matrix, you are able to <u>imagine</u> the position of a cell in the matrix upon hearing its name. At this time, please familiarize yourself with the cell positions and their associated labels (<u>S</u> was allowed, up to 1 minute for study). During the experiment, you will be required to imagine the matrix without the aid of a printed matrix.

Basically, your task for the present study will require that you visually imagine a number being traced out in the matrix, by imagining you have drawn a line, connecting each of the cells you hear called out over the tape. The sheet I an now giving you illustrates how this is to be done (Appendix C). Please note, what appears on the left side of the sheet is what you will hear, while you are to imagine what appears on the right side of the sheet. Keep in mind that, throughout the experiment, you will not have the aid of any printed material to accomplish your task. It must be done entirely with your imagination. The next sheet I am giving you illustrates the idea that, in some instances, you may have to imagine going back over an already imagined line (Appendix D). This is illustrated in the last three moves required to trace out the number one.

This sheet illustrates how the number one to nine would look if traced out in the matrix, using the cell names (Appendix E). For each number, I would like you to call out the cells of the matrix the number occupies, in the order indicated on the sheet, to familiarize yourself with the numbers and their associated cell names.

Now, I would like you to, using the printed matrix (Appendix B), to place your finger on the first cell you hear called out and continue tracing from cell to cell as the remaining cells are called out, telling me what number has been traced out. After the last cell has been called out, I will say start. This is your signal that the message is over and also your signal to respond.

Now, would you please look at the number five on the sheet of numbers placed in the matrix (Appendix E), noting the cells of the matrix which the number occupies. Now, without looking at the sheet, and beginning at the 12 o'clock position, would you trace out the number five, by calling out the appropriate cell names. Do you have any questions up to now?

If there are no questions, we are ready to begin a series of eight practice trials. But, before we begin, let me inform you of the sequence of events as they will occur on each trial. The sheet I am now giving you is a pictorial representation of a trial (Appendix F). At the beginning of each trial, you will hear "ready" called out over the tape. At this time sit forward, placing your chin in the chin rest, folding your hands together. "Ready" will be followed by a blank interval of variable length. At the end of the interval, a cell name will be called out, over the tape. This indicates the cell of the matrix you should begin imagining from for that trial. There will then be a two second delay, allowing you to form an image of the matrix, and your starting point in it. Following this delay, the remaining cells required to trace out the number will be called out, at a rate of two cells per second. After the last cell you will hear "start" on the tape. This signals that the number has been traced out, as well as indicating the beginning of the response period. After hearing "start", you will hear "one", "two", "stop" at one second intervals. Upon hearing stop, remove your chin from the chin rest and sit back and relax, until you hear the next ready. It is extremely important that you call out the number you believe was traced out, before or simultaneous with hearing "stop" over the tape. Any response made after "stop" has occured will be counted incorrect. Following the end of each trial, there will be a delay of approximately 20 seconds before the beginning of the next trial. Are there any questions?

If not, let me give you some additional instructions and information before we begin. First, throughout the practice trials, I would like you to sit, hands folded together, from the time you hear "ready" until you hear "stop" for each trial. Next, let me repeat that it is important that you respond on each and every trial, even if your response is a pure guess. There is no penalty for guessing. But, respond before or simultaneous with hearing "stop" on the tape. Further, all trials will trace out a number in a manner similar to the way the number would be written on a piece of paper. Numbers will not be traced out upside down, backwards, etc. Before we begin, let me say that the task was designed to be difficult, so don't get discouraged. Are there any questions? If not let's begin.

Instructions for the last four practice trials

For the remaining four practice trials, everything will be the same, except that on each trial, I would like you to (tap your finger) in time with the metronome

(blink your eyes)

(not blink your eyes)

(beginning when you hear ready on the tape, continuing

(beginning when you hear the first cell called out,

until the first cell is called out), following this period continuing until you hear stop),
(return to normal eye activity), once again. The sheet I
(fold your hands),
am now giving you illustrates this change in procedure (Appendix G and H).

This concludes the practice trials. For the experimental trials, everything will be the same as in the last four practice trials, with the exception that instead of tracing out numbers, the sequences will trace out block capital letters. Here is a sheet illustrating how each letter of the alphabet would look in the matrix, if traced out using a sequence of cell names (Appendix I). Please note, several letters are not traced out. These letters will not be used in the experiment. Take a moment to study the sheet of letters, by calling out the names of the cells that each letter occupies, in the order indicated on the sheet.

Before we start, let me remind you, that all trials will trace out a letter, and that the letters will not be upside-down, backwards, etc. Also, let me once again emphasize the importance of responding within the alloted time, guessing if you have to. Are there any questions? If not, let's begin.

APPENDIX B

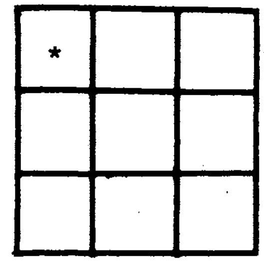
THE MATRIX AND CELL LABELS

UP LEFT	12 O'CLOCK	UP RIGHT
9 O'CLOCK	CENTER	3 O'CLOCK
DOWN LEFT	6 O'CLOCK	DOWN RIGHT

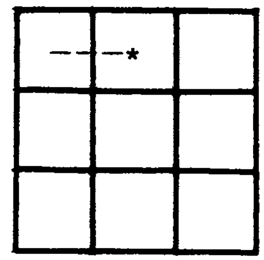
APPENDIX C

EXAMPLE OF A NON-OVERLAPPING MESSAGE

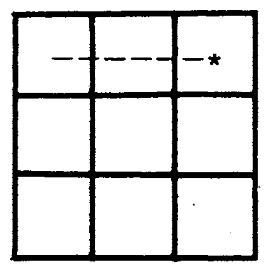
"UP LEFT"



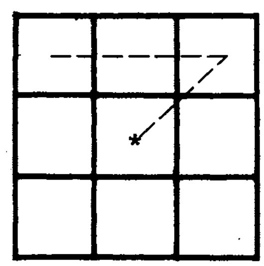
"12 O'CLOCK"



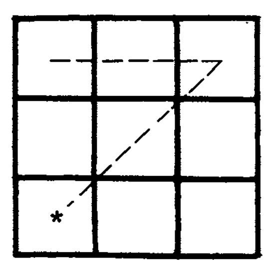
"UP RIGHT"



"CENTER"



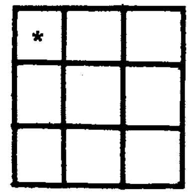
"DOWN LEFT"



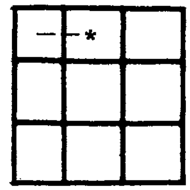
APPENDIX D

EXAMPLE OF AN OVERLAPPING MESSAGE

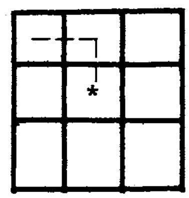
"UP LEFT"



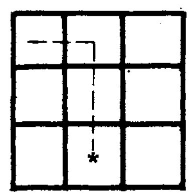
"12 O'CLOCK"



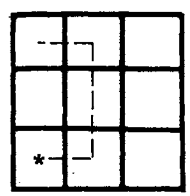
"CENTER"



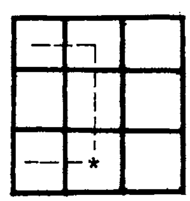
"6 O'CLOCK"



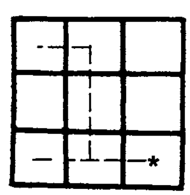
"DOWN LEFT"



"6 O'CLOCK"

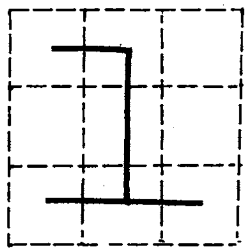


"DOWN RIGHT"

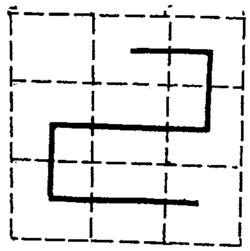


APPENDIX E

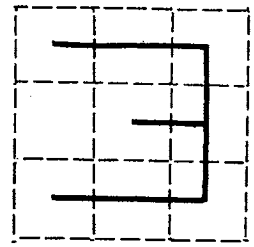
THE NUMBERS 1 TO 9 PLACED IN THE MATRIX



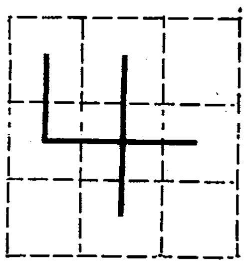
1



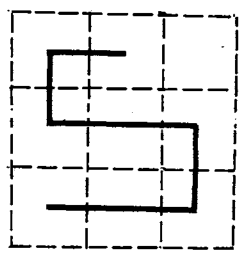
2



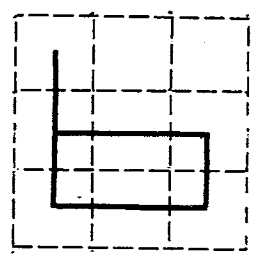
3



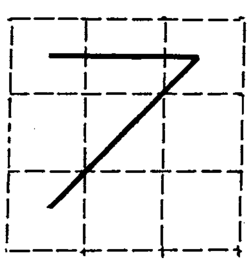
4



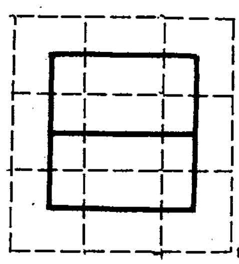
5



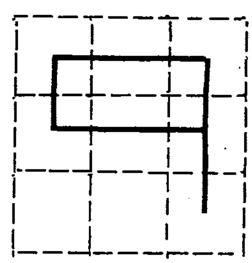
6



7



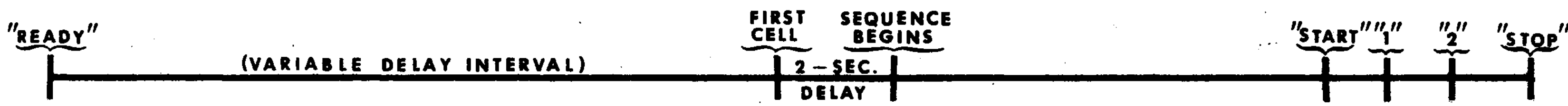
8



9

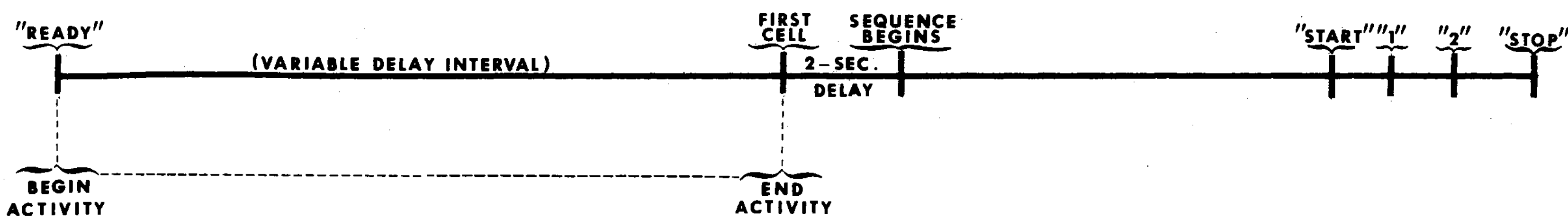
APPENDIX F

SCHEMATIC OF A TRIAL WITHOUT CONCURRENT ACTIVITY


"READY"
(VARIABLE DELAY INTERVAL)
FIRST CELL
2 – SEC. DELAY
SEQUENCE BEGINS
"START"
"1"
"2"
"STOP"

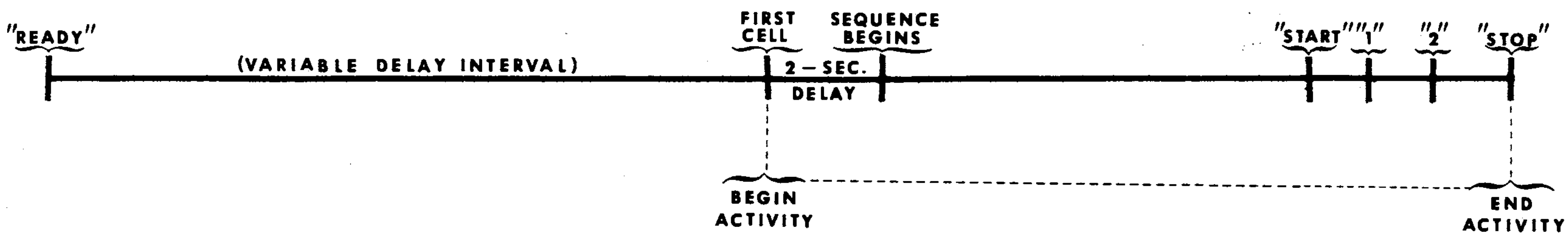
APPENDIX G

SCHEMATIC OF A TRIAL WITH PRE-TASK CONCURRENT ACTIVITY


"READY"
(VARIABLE DELAY INTERVAL)
FIRST CELL
2-SEC. DELAY
SEQUENCE BEGINS
"START"
"1"
"2"
"STOP"
BEGIN ACTIVITY
END ACTIVITY

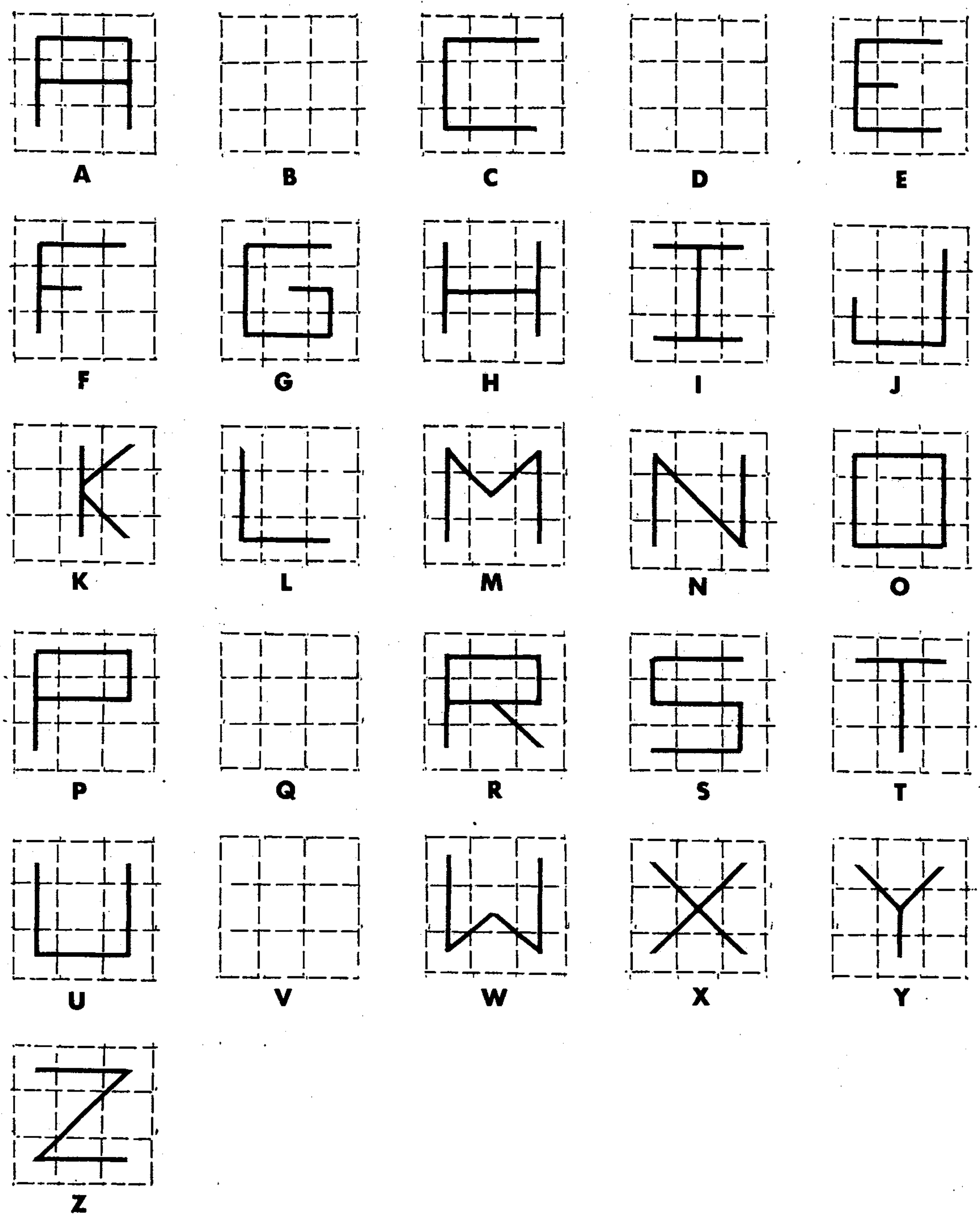
APPENDIX H

SCHEMATIC OF A TRIAL WITH TASK CONCURRENT ACTIVITY


"READY"
(VARIABLE DELAY INTERVAL)
FIRST CELL
SEQUENCE BEGINS
2 – SEC. DELAY
"START"
"1"
"2"
"STOP"
BEGIN ACTIVITY
END ACTIVITY

APPENDIX I

LETTERS OF THE ALPHABET PLACED IN THE MATRIX


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X
Y
Z

APPENDIX J

A SELECTIVE REVIEW OF RECENT IMAGERY RESEARCH

The study of imagery and imaginal processes has become an increasingly popular endeavor in the past few years. To convince oneself of this, one only needs to peruse the recent psychological literature. There are a number of books and journal articles summarizing imagery research up to and, in some instances, including 1971 (Bower, 1972; Bulgelski, 1970; Horowitz, 1970; Paivio, 1971; Reese, 1970; Segal, 1971; Sheehan, 1972). In light of existing reviews, the scope of the present paper will be limited to an examination of imagery research occurring from 1971 up to the present. As Kessel (1972) notes, the zeitgeist within psychology has become cognitive-experiential in nature, resurrecting images as a legitimate output of the "psychic black box". However, along with the revival of imagery as a legitimate area of study for psychologists, has come controversy over the nature of imagery. The traditional conception, that of an image being a mental picture, has been supplanted by alternative conceptions offered by Neisser (1972) and Pylyshyn (1973).

Neisser (1972) contends that the classical conception of imagery is much akin to the classical theories of perception. That is, imagery, like perception, is like looking at pictures, but looking at them for the second time. It is his contention that imagery is a constructive process, much like the current thinking with regard to perception. Neisser's (1972) views with respect to imagery processes and the visual image derive from Gibson's views on perception. Gibson contends that it is the function of vision to provide information about the layout of the environment through various cues, rather than to provide a two-dimensional mossaic which is, in turn, interpreted by higher order processes. Neisser (1972), in line with the ideas advanced by Gibson, takes the position that, psychologists should stop talking about images as being mental pictures, and begin viewing them as mental layouts. However, Neisser (1972) does not, as does Gibson, discount higher order processes in the representation of the environment, constructed on the basis of available cues. Like Pylyshyn (1973), Neisser (1972) feels that introspection, a technique still used to study imagery, is laden with problems and has aided in perpetuating the view of the visual image being a mental picture. It is claimed that the emphasis in present day cognitive psychology, an approach emphasizing mental processes, has changed the conception of the brain from that of a storehouse to that of an organ with various functions, which in turn necessitates a change in the views of what imagery is. Imagery now becomes, not mental contents awaiting description, but a form of mental activity which is immensely complex, involving rapid changes and a myriad of interrelations in the brain. Because of this inferred complexity, Neisser (1972) contends that what is reported through introspection is somewhat arbitrary, even if it is assumed that all processes are, in some sense, available to the subject. Because of the problems arising with introspection, psychologists turned to behaviorism, which ignored, or flatly denied many of the characteristics of human beings, which, in fact, sets them apart from other living organisms. However, in the last few years, a paradigm shift has occured, placing emphasis on how information is processed. At present, concepts like rehearsal, mnemonic strategy, encoding, and imagery are the items of interest, as opposed to the behaviorist's emphasis on stimulis variables. Of these mnemonic strategies and processes that have been recently investigated, none has been studied more than imagery, judging from reported research over the past several years. Such studies have indicated the importance of an individual's mental activities in relation to his performance, while indicating that the most powerful of such activities may well be visual representation. The realization that visual representation is an effective mnemonic device is viewed (Neisser, 1972) as creating opportunities as well as dangers. The danger spoken of is that of oversimplification, with respect to imagery. That is to say, imagery has been characterized as having a single set of properties quite distinct from those of verbal processes. The feeling (Neisser, 1972) seems to be that such a conception is misleading, in that, while imagery may have some unique properties, it may also have properties in common with other forms of mental representation. Other indications of an oversimplified view of imagery processes are apparent if one considers some questions, with respect to imagery, that have not been asked (Neisser, 1972). Among such questions are: does imagery differ among children and adults; may there be more than one kind of imagery; and how might the various types of imagery interact to enhance or detract from performance, in contrast to performance dependent upon only one form of imagery? Then too, studies involving investigation of individual differences in imagery ability have revealed that inter as well as intra-individual variation may be quite marked, suggesting that imagery may be a more complex process than is now thought.

Neisser (1972) points out that the view that the brain is an organ whose function is to process information, necessitates that the information reaching it through the sense organs must be analyzed, abstracted, coded and reworked, in such a manner so as to preserve critical information, while not overloading it. It is contended that imagery, while it might be visual, in some sense, need not be pictorial. That is to say, if imagery involves the picking up of spatial information about the environment, as opposed to merely copying it, subjects should be able to imagine layouts which could not be pictured (e.g. a situation in which an object is in front of, or concealed by another object).

Neisser & Kerr (1973) have reported some results which point to the notion that images may, in fact, be spatial, while not necessarily being pictorial. Subjects were asked to imagine a variety of spatial situations (pictorial-interacting; pictorial-separate; and finally, "concealed images"). After subjects imagined each scene, they were then asked to rate that image for its vividness. Following this, subjects were asked to recall the scene, given a cue from the sentence which described it. It was predicted that the pictorial and concealed conditions should result in equally good recall, and that the recall for the "separate" image condition should be inferior to both. Finally, rated vividness of pictorial images should be higher than the rated vividness of the concealed images, on the assumption that ratings would be based on the subject's expectancies of what images were, rather than on well defined aspects of their mental processes. The predications were confirmed, with regard to recall: the pictorial-interactive and concealed conditions did not differ from one another, but both were significantly greater than the pictorial separate condition. The predictions with regard to vividness ratings, however, were not confirmed. The pictorial-separate and concealed condition ratings did not differ significantly, while the interactive ratings were significantly higher than either the pictorial-separate or the concealed condition ratings.

Neisser & Kerr (1973) interpreted the results as indicating that images need not be pictorial in nature, and that the result is consistant with notions as to the nature of imagery as presented by Neisser (1972). Namely, imaging is a constructive process which is actively related to perceiving, and further, that imagery is not simply the examination of a simple mental picture, but rather, involves information pickup about the layout of the environment.

To summarize Neisser's (1972) position: imagery is viewed as occurring whenever an individual employs some of the same cognitive processes that would be used in perceiving, but that such processes need not be accompanied by introspective report of picture-like mental contents, or the stimulis input that would normally give rise to such perception. Imagery is viewed as a constructive process, in that, while it depends on information stored earlier, it does not simply revive that information. Instead, the subject carries out a new activity, perhaps forming a new representation, more or less consistant with what he had seen before.

More recently, another investigator has questioned the classical and most prevalent view of the nature of imagery. Much like Neisser (1972), Pylyshyn (1973) has attacked the generally accepted notion that the image is pictorial in nature. It is argued, much like the views of Neisser (1972), that the fact that introspective reports on the use of imagery (in its common sense) do not necessarily point to imagery being a pictorial representation, even though such reports usually indicate picture-like phenomenon. The argument is, just because it is reported that we say things to ourselves, or "see" objects in our mind's eye, it cannot be assumed that such activities are the actual information processing procedures taking place. Pylyshyn (1973) attacks the assumption, abounding in research, that what is functional is available to introspection, arguing that just because our memory for cognitive events appears limited to sensory-motor images, this does not mean that these are the processes which are operative. Pylyshyn (1973) states that the above assumption appears to have led most psychologists to the feeling that there are no forms of mental representation other than words or images. Additionally, Pylyshyn (1973) feels, as does Neisser (1972), that some mental representations may be such that they are not amenable to observation from within or without. The fact that humans have the ability to transform mental pictures into mental words, and vice-versa, indicates that there must be a form of mental representation which encompasses both mental words and mental pictures. Further, it is contended that such an encompassing mental representation must necessarily be more abstract and not consciously available. Pylyshyn (1973) feels, to assume that mental words and images are linked by direct associative connections is untenable, in that words are generic while images are specific. Based on this assumption, it is thought that an infinite number of links would have to be formed for a given word, and each possible instance of the concept. However, there are those (Paivio, 1971a) who contend that an image need not necessarily be specific. In line with this contention, Paivio (1971a) states that images may, in fact, be schematic forms of representation, with the specificity of the image being derived from the ongoing situation. This latter conception of the image (Paivio, 1971a) appears to be consistant with Neisser's (1972) views as to the nature of visual imagery. To Pylyshyn's (1973) thinking, the image must necessarily be something other than visual. Basically, the contention seems to be that some sort of pictorial representation may be aroused, but not directly. Rather, what is commonly referred to as an image, is derived from a person's knowledge stored in the form of prepositional statements of some uncharacterizable nature.

Pylyshyn (1973) agrees with Atwood (1971), that the most elementary question that be asked about mnemonic visualizations is the following: does the mnemonic image actually involve the visual system? Atwood (1971), using the method of selective interference concludes that it does. Pylyshyn (1973) feels that while this conclusion may be sound from a phenomenological standpoint, it is unsatisfactory as an explanation of how information is retrieved from memory, for several reasons. First, the storage of sensory material in a "raw" state would endow the brain with an incredible storage capacity. Secondly, such a position would imply that retrieval would take place by either some sort of scanning process, or through some system whereby images are retrieved by use of gross labels, tagging each image. The first of the suggested retrieval systems is seen as untenable, in that exhaustive search would be too slow a process. Also, Pylyshyn (1973) contends that introspective reports do not indicate that information is retrieved only after a series of false starts. This latter objection seems somewhat strange, in that Pylyshyn (1973), in presenting his arguments, has stated that introspective experience need not actually reflect the actual ongoing processes. The second possibility, that of retreival via a "tagging" mechanisms, is dismissed on the grounds that retrieval of images appears to be hierarchical. Here again, it appears that Pylyshyn (1973) is again appealing to introspection, a technique he has critisized, to make his point. The question, for Pylyshyn (1973), then becomes, if visual images are not pictorial representations, what are they? For Pylyshyn (1973) the answer seems to be that they are descriptions of scenes, rather than pictures of them. That is to say, images are not photograph-like, thereby being amenable to perceptual analysis. Rather, images are products of sensory datum which has been perceptually analyzed and stored in some form (e.g. propositions, data structures or procedures).

While both Neisser (1972) and Pylyshyn (1973) have taken issue with the classical notion of imagery being nothing more than mental pictures, both seem to admit that the process known as imagery does involve, in some way, spatial relations. Neisser (1972), it seems, has taken the position that images, while not being pictorial, are some sort of visual representation (layouts of the environment). Pylyshyn (1973), on the other hand, maintains that imagery is essentially propositional in nature, but that it can give rise to some sort of visual representation. The concession that imagery may be something other than visual in nature, that imaginal processes can give rise to some form of spatial representation, seems necessary in light of existing empirical evidence. The existing empirical evidence referred to are those studies employing the technique of selective interference (Atwood, 1971).

One such study (Wegmann & Weber, 1973) had subjects imagine block capital letters being traced out in a matrix, by means of a series of cell names (cells of the matrix). One half of the subjects were presented the cell moves auditorially, while the remaining half of the subjects read the same cell moves from index cards. Results indicated that the performance, in terms of percent of letters correctly identified, was significantly greater for the subjects receiving auditory presentation, relative to those subjects receiving visual presentation of the to-be-processed material. The data was interpreted (Wegmann & Weber, 1973) as indicating that visual presentation, in some fashion, overloaded the visual system, such that capacity for imagery was reduced.

Other evidence that imagery is, in some sense, visual comes from a study by Kosslyn (1973). It was argued that if images are spatial representations of their referents, several testable hypotheses are possible. One, subjects should be able to focus selectively on part of an image. Two, time would be required to shift from one part of the image to another. Finally, the farther a given property is from another property in an image, the longer the shift of attention from one to the other should take. Accordingly, subjects were shown pictures under imaginal or verbal encoding instructions. Additionally, each instruction group was told to either focus their attention on a specific portion of the image or the verbally encoded material, or to maintain an overall idea of the material. Subjects were then asked questions about the pictures with response latencies taken. Results indicated that for the focus groups, response latencies were a linear function of the distance of the probed item from the subject's focus, with the verbalization group having longer response latencies, on the average, than the imagery group. Functions for whole imagers and verbalizers were essentially flat, with the verbal group again having longer response latencies. Also, the positive slope of the function for the verbal focus group was considerably greater than the slope for the image focus group. This latter result was interpreted as indicating that subjects in the image group were able to employ some parallel processing as opposed to the verbal group. Additionally, the fact that the functions of the whole groups were essentially flat, with the verbal function above that of the image group suggests that the verbal group had to transform material encoded verbally to a pictorial representation prior to making their response. In light of the arguments presented by Neisser (1972) and Pylyshyn (1973), and the empirical evidence cited, it seems that imagery does have spatial properties, be they directly or indirectly aroused.

Another aspect of imagery research that has seemingly received a great deal of attention in the past has been with regard to the function of imagery, rather than with respect to its nature. One of the most active investigators in the area of imagery research has been Allan Paivio. Initially, Paivio's work centered around the function of imagery within standard verbal learning situations. More recently, however, Paivio has begun to look at the findings of his researches in terms of the functional distinction between imagery and verbal processes. This more general approach has led Paivio to view verbal and imaginal processes as alternative memory coding systems, and to consider the functional significance of imagery for a general theory of memory. Paivio (1972a) points out that the imagery value of stimuli has been shown to be an effective variable in paired associate learning, verbal discrimination learning, free recall, serial learning, and the Brown-Peterson paradigm. He rejects both motivational and verbal interpretations of the effect of imagery. The former interpretation is rejected in that imagery effects remain undiminished in incidental learning situations. The verbal interpretation of imagery effects is rejected in that, the effects of meaningfulness and frequency are weaker than the effects of concreteness, in addition to having effects which sometimes run contrary to the effects of concreteness.

Paivio's (1972a) observations as to the differences between imagery and verbal processes have led him to propose a two-process theory of memory. This two-process approach states that the ease of image generation is a function of item concreteness, while verbal coding or mediation would be independent of concreteness, and instead, related to associative meaningfulness. Reaction time data support the contention. The hypothesis implied that part of the imagery effect can be attributed to the ease of image discovery. Findings indicate that it takes longer to generate images to abstract versus concrete nouns. For verbal mediators, however, it has been shown that associative latencies do not vary as a function of concreteness. It has been suggested that the sometime superiority of imagery mnemonics cannot be explained solely by encoding factors. This is due to the fact that evidence (Paivio & Foth, 1970) has been reported, indicating that imaginal encoding was superior to verbal encoding for concrete noun pairs, even though the verbal and imaginal mediators were discovered equally quickly. Therefore, ease of encoding does not provide an adequate explanation of the frequently reported superiority of imaginal over verbal encoding. Further, encoding instructions appear to be overridden by the meaning attributes of stimuli, with imagery being the preferred strategy, when at least one member of a word pair is rated high in imagery value. In contrast, only verbal mediators are available for abstract pairs. Therefore, both visual and verbal encoding processes are implicated in the effects of concreteness and imagery mnemonic instructions on performance.

Wicker and Holley (1971) reported some results which seem consistent with a dual coding position. Subjects learned mixed paired associate lists, with imagery or no encoding instructions. Lists consisted of 15 word-word pairs, each pair having auditory, visual or no distractor type. Results indicated that visual distraction pairs had a greater negative effect with pictorial versus verbal stimuli. In contrast, auditory distraction had an equal negative effect on the recall of either picture-word or word-word pairs. It was concluded, (Wicker & Holley, 1971) that the results were consistant with a dual encoding hypothesis, while indicating the greater use of imagery mediation for pictorial stimuli.

Also, Paivio and Csapo (1971) showed lists of concrete words, abstract words, and pictures at a fast rate (5.3 items per sec.) or at a slow rate (2 items per sec.). It was expected that recall would differ, at the fast rate, for the different types of stimuli, in that the subjects would not be able to encode items verbally. On the other hand, the slower rate of presentation should result in smaller recall differences, in that all stimuli types would be verbally encoded. Results for the fast rate of presentation indicated the typical finding for sequential memory tasks: concrete words were recalled best, followed by abstract words and then pictures. At the slow rate of presentation however, there were no significant differences for recall of concrete words, abstract words, and pictures. It was assumed that both the visual and verbal codes were available for concrete words and pictures, but differentially so. It takes more time to label a picture than to read a word. Therefore, at the fast rate of presentation, the verbal code was less available for pictures. The verbal code, on the other hand, is the only code available for abstract words. It was concluded (Paivio & Csapo, 1971) that the results provided support for a dual coding position for memory.

A further test of the dual-encoding hypothesis was conducted by Paivio and Csapo (1973), in a series of five experiments. In experiment I, subjects learned lists of pictures and words under intentional learning, incidental learning, or free recall instructions. The orienting task required subjects to write down the word presented, or a word labelling the picture presented. The nature of the orienting task, it was reasoned, would insure verbal encoding. A significant stimuli by conditions interaction revealed that performance for free recall, intentional and incidential groups was about equal. However, for concrete versus abstract word recall, the free recall group recalled the most words, followed by the intentional and incidental groups respectively. These results were interpreted as indicating that, for pictures, the orienting task insured that both visual and verbal codes were aroused, and hence, resulted in similar performance for each group. In the case of word stimuli, however, the orienting task drew attention, primarily, to the verbal code, and differences in recall performance for the groups appear, with free recall being the best and incidental learning the worst. In sum, the results (Paivio & Csapo, 1973) of experiment I were interpreted as being consistant with a dual coding position, while not ruling out other possibilities.

In experiment II (Paivio & Csapo, 1973) all subjects were given an incidental learning task. Groups of subjects were required to learn items (pictures or words) under one of two orienting tasks (drawing the item versus verbally labelling the item). It was predicted that performance for the picture-label and word-draw conditions should be superior to picture-draw or word-label conditions (if a dual encoding notion holds). It was found that for picture stimuli, the orienting task made no difference on performance, while for word stimuli, the performance of the word-draw group was markedly superior to that of the word-label group.

A third experiment (Paivio & Csapo, 1973) was conducted, the conditions being the same as those of experiment II, with the exception that subjects were told, explicitly, to form visual and/or verbal codes to the stimuli. Results of experiment III were similar to that of experiment II. In summary, the results of experiments II and III (Paivio & Csapo, 1973) indicate that dual coding of pictures or words was not superior to imaginal coding of pictures. This suggests that a concrete image may account for the superior recall of picture stimuli, as well as imaginally versus verbally encoded words. The latter result also attests to the potency of mental imagery as a mnemonic strategy.

In conclusion, the results of experiments I-III appear consistant with an image superiority hypothesis, or some synthesis of an image superiority hypothesis and dual coding hypothesis. The results of experiments IV and V (Paivio & Csapo, 1973) indicated that pictures were recalled better than words and that repetitions could enhance recall. Also, the evidence indicated that the two codes were independent and additive. Generally, the results of the five experiments (Paivio & Csapo, 1973) indicated that the superiority of pictures versus word recall can be explained by a dual coding hypothesis, with imaginal encoding yielding a relatively greater contribution to performance. Two possible classes of explanations were offered. First, the superiority of pictures may be due to the fact that "inter-item" associations among words may be interfering. Alternatively, organization could be a factor. It could be the case that pictures lead to more efficient organization and chunking, and therefore, less memory load. Most important, however, the results (Paivio & Csapo, 1973) were interpreted as providing support for two major systems of memory and cognition, that are independent and yet functionally related.

Additional support for the existance of visual and verbal systems comes from a study by Murray and Newman (1973). Subjects were shown matrices containing a square, circle and triangle, which they had to reproduce in a blank matrix, after different retention intervals, filled by different interference tasks. It was found that recall performance decreased as interference went from verbal interference to visual interference to visual plus auditory interference.

Also, a study by Elliott (1973) provides additional evidence for both visual and verbal encoding of information, by demonstrating selective interference effects. Subjects were shown triads of either high or low imagery words after which they engaged in one of several interpolated tasks (no interpolated activity, Peterson-Peterson task-auditory interference, or reproduction of geometric figures-visual interference) while using rote or imaginal mnemonics in remembering the items in the triads. The results indicated that the imagery set resulted in better recall, relative to the repetition set. However, facilitation by the imagery set was greater for high versus low imagery words. It was also found that the number task caused more interference in the repetition condition, while the visual imagery condition was most greatly affected by the visual language task. It was concluded (Elliott, 1973) that the results indicated distinct visual and auditory-motor storage systems in memory. Numerous other studies have also presented findings consistant with a dual coding hypothesis (Atwood, 1971; Weber & Kelley, 1972; Weber, Kelley & Little, 1972; Seamon, 1972; Nelson & Brooks, 1973; Hall, Swane & Jenkins, 1973; Mondani & Batting, 1973; Segal & Fusella, 1971; Siegal & Allik, 1973; Horwitz & Levin, 1972).

On the basis of the above discussion, it would appear that the recall superiority of pictures over concrete nouns over abstract nouns may be due, in part to organizational processes based on imagery. In line with this thinking, several investigators have obtained results that indicate the importance of figural unity or integration of the mediating image. Bolt (1971) reported, in a series of three experiments that subjects were able to recall more cues for organized versus unorganized pictures. Additionally, Morris and Reid (1971) reported that, in a paired associate task, noun imagery facilitated recall, only when the word pair was compatible (e.g. such that an image of the two items of the pair could be easily formed). Therefore, figural organization may be the basis for the observed superiority of imagery mnemonics over verbal mediation, for dealing with concrete nouns. If the S-R association is stored as a compound image, and the image is reinstated, it can be quickly scanned to produce the appropriate response. On the other hand, verbal mediators must be stored with the appropriate stimuli and responses, as a string of words (this may result in a greater memory load and/or longer search time, and therefore, less efficient retrieval).

Griffith and Johnston (1973) had subjects engage in a paired associate learning reaction time task, concurrently, under imaginal or rote instructions. Results indicated that imagery instructions resulted in better recall, relative to rote instructions, as did the recall of high imagery items, relative to low imagery items. Also, extra pair confusion was less for the imagery set, only on study trials, while being less for high versus low imagery items during recall. Therefore, it appears that imagery set and imagery value, while affecting recall in a similar way, had affected different phases of the task. On the basis of the findings, Griffith and Johnston (1973) hypothesized that imagery set may have affected encoding, while the imagery value of items might have made responses more "functionally" available.

Also, it seems possible that the facilatory effects of imagery may be due to differential intreverbal interference. In this context, it has been thought that instructions to form bizzare images could reduce interference while increasing distinctiveness. However, research on bizzareness has been conflicting, although recent investigations would appear to indicate that the bizzareness of images does not aid in reducing interference or serves to make images more distinct. Collyer, Jonides and Bevan (1972) had subjects recall a noun-verb-noun triplet, under imagery instructions (bizzare versus common). Results indicated that the common instruction and the imagery instruction resulted in better recall. It was hypothesized that formation of a common image would provide the subject with a greater probability for recall.

Another study (Wollen, Weber & Lowry, 1972) sought to investigate the effects of interaction and bizzareness of mental images, and their effects on recall. Subjects engaged in a picture paired associate task, in which the pictures were bizzare or common and interacting or non-interacting. Results indicated that interacting pictures resulted in better recall, but that bizzareness had no effect. It was suggested (Wollen, Weber & Lowry, 1972) that previous research, indicating the effectiveness of bizzareness, may have confounded bizzareness and the interaction of images.

A subsequent study (Nappe & Wollen, 1973) using cued paired associate recall, again indicated that bizzareness did not result in better recall. However, it has been reported by numerous investigators, that interaction of stimulis-response items (imaginal or pictorial) does have a facilitating effect on recall. Wollen and Lowry (1971) reported a facilitation of recall for noun-noun pairs when accompanied by pictures which depicted the pair items interacting, but no such facilitation when the pair items shown in the pictures were not interacting, or when the items appeared in separate pictures. It was suggested (Wollen & Lowry, 1971) that interacting pictures facilitated associative encoding of the stimulis and response items.

Bower and Reitman (1972) had subjects learn five successive lists of 20 words, under separate images (peg-word method), elaboration of images (peg-word method), or by the method of loci instructions. Generally, it was found that recall was poorer for the separate images condition. This was interpreted as implying that, as the number of contexts increases, recall decreases and that interacting images have a facilitory effect on recall.

Lesgold and Goldman (1973), however, reported some results which appear to conflict with the results reported by Bower and Reitman (1972). Subjects generated interactive images to triplets of concrete nouns, under common instance or pair specific instructions. Results indicated that as the number of contests increased, the recognition percentage increased. Similar results were observed in a subsequent experiment, which required recall rather than recognition. While the results of the Bower and Reitman (1972) study appear to be at odds with results obtained by Lesgold and Goldman (1973), it should be noted that the tasks in the two studies are somewhat discrepant. In line with this it has been suggested that different tasks may call forth different types of imagery strategies.

The role of imagery in learning and memory is both conceptually and empirically clearest in associative retrieval. The conceptual-peg hypothesis of paired associate learning is essentially a retrieval theory. The theory views the function of the stimulis term as being that of a peg to which the response is "hooked", and the more solid the peg, the better the recall. The theory assumes that the ease of image mediated association is related to the concreteness of the to-be-associated events, and in particular, to the concreteness of the retrieval cue. Further, it is assumed that the concreteness of both the stimulus and response items are equally important during storage, but that it is the concreteness of the stimulis item that is most important during retrieval.

Jacobus, Leonard and Stratton (1971) investigated the effects of imagery in the paired associate learning of adjectives. In two experiments (the first using unmixed lists-with regard to imagery and the second using mixed lists) using a paired associate task, it was found that for unmixed lists, results were similar to those found for the paired associate learning of nouns, but indicated that response imagery tended to be more effective than stimulus imagery. These differences suggest that imagery may have different effects for adjectives as opposed to nouns. However, some results, discrepant from those just discussed had been previously reported by Di Vesta and Ross (1971). Subjects differing in imagery ability, as measured by spatial reasoning tests, learned paired associate lists of noun-adjective or adjective-noun pairs. The findings (Di Vesta & Ross, 1971) showed noun-adjective recall to be superior to adjective-noun recall, and also, that with regard to the response position, noun imagery was more critical than adjective imagery. Further, the results indicated that the effects of imagery on stimulus items, relative to response items, was more important for the former, regardless of whether the stimulus item was an adjective or a noun. The results (Di Vesta & Ross, 1971) were interpreted as indicating that the imagery value of nouns is more closely linked to paired-associate learning than the imagery value of adjectives, and that stimulus imagery is more important than response imagery.

The peg hypothesis also implies that, in free recall, members of a pair should be equally well recalled. This has been confirmed by Yarmey and Ure (1971). Also, there should be no differential effect of concreteness in a matching test, in that, either member of the pair could function as the retrieval cue. This latter prediction has been confirmed by Paivio and Rowe (1971). While on the basis of the above findings, the conceptual-peg hypothesis seems plausible, the evidence does not conclusively point to imagery mediation. Explanations could be made in terms of stimulus differentiation or recognition, rather than association. However, reported results from several recent studies would appear to strengthen the mediation position. Bower (1971) found recall to be better for subjects asked to imagine items of noun pairs as interacting with one another, as opposed to imaging each item seperately. Further, the relationship held, even when only recognized stimuli were considered. Additionally, Rowe and Paivio (1971) found that instructions to image only to the correct member of a noun pair, versus imaging to both members (with the correct member imagined as being larger), enhanced recall. However, in an unexpected associative recall task which followed, the group imaging to both items of a pair displayed superior recall. Results were interpreted (Rowe & Paivio, 1971) as indicating that imagery can facilitate both verbal discrimination as well as associative learning, with the type of imagery that is effective, differing markedly for the two tasks.

Other sources of evidence for an imagery interpretation of the effects of imagery come from results reported by Phillipchalk and Paivio (1971) and Paivio and Okovita (1971). In the former study, subjects learned to associate nonsense syllables to either pictures, concrete or abstract nouns. The syllables were then used as stimuli for a subsequent paired-associate learning task, with the subjects told to use associations from the first phase of the study as mediators, or with subjects given no instructions at all. It was found that paired-associate learning, for the group receiving mediation instructions, was best for those that had associated the nonsense syllables to pictures, then concrete words, and finally abstract words. Such differences were not found for the no mediation instruction group. The results were interpreted as indicating support for an imagery interpretation of concreteness effects. Paivio and Okovita (1971) found that congenitally blind subjects learned high auditory imagery words better than low auditory imagery words (even when the latter were high in visual imagery). In contrast, sighted subjects benefited from visual, but not auditory word imagery. The finding that sighted subjects were able to benefit from visual word imagery, but not from auditory word imagery is somewhat mysterious, and deserves further investigation. At any rate, Paivio and

Okovita (1971) interpreted their findings as indicating that learning was mediated by modality specific images.

The effects of imagery in verbal discrimination learning has also been investigated, in a series of studies by Allen Paivio and E. J. Rowe. In the first of the studies Rowe and Paivio (1971a) the effects of imagery versus repetition instructions was studied. Subjects were shown pairs of high imagery, high frequency words (the correct one underlined) with instructions to: form a single image to the correct item; form a compound image of the word pairs; or to repeat the correct item verbally; or no instructions. Subjects were then supplied lists of the correct or incorrect items and asked to supply the other word of the pair. Results indicated that both imagery conditions proved to be effective mnemonics, but that forming a single image was most effective. For associative learning, formation of a compound image was most effective. Further, it was found that the compound image condition was less affected by the cue in associative learning. This latter result would suggest that the imagery effect is in the associative phase of paired associate learning.

A second study (Rowe & Paivio, 1971b) consisted of a series of four experiments in which the frequency and imagery value of words were factorially varied over two levels. In summary, the results indicated that high imagery noun pairs were significantly easier to learn than low imagery noun pairs, for both mixed and unmixed lists. This result was limited to high frequency words in two of the four experiments. Also, in two of the experiments, high frequency words were easier to learn (limited to low imagery word pairs in mixed lists). Additionally, the second experiment indicated that the imagery strategy was preferred for high imagery word pairs, while the repetition strategy was preferred for low imagery word pairs. It was concluded (Rowe & Paivio, 1971b) that imagery had a strong effect in all cases, while frequency showed an effect for a restricted range of frequency values, in mixed list design. Moreover, when frequency had a significant effect, it was restricted to low imagery pairs. In summary, it was concluded (Rowe & Paivio, 1971b) that frequency, as indexed by Thorndike-Lorge is ineffective in verbal discrimination learning.

Rowe & Paivio (1972) studied the effects of noun imagery, pronounciation, method of presentation and intrapair order of items in verbal discrimination learning. The study represented an attempt to examine the generality of the imagery effect in verbal discrimination learning. Subjects were shown pairs of high and low imagery words under combinations of several conditions: study-test versus anticipation; pronounciation of list pairs; and constant or varied order of pair members. Results indicated that high imagery word pairs were easier to discriminate than low imagery word pairs, and that learning was facilitated when pronounciation was not required. Additionally, the method of presentation (study-test versus anticipation), and constant or varied intrapair ordering were relatively unimportant. This latter result was interpreted (Rowe & Paivio, 1972) as indicating that the explanation of imagery effects in verbal discrimination learning is to be found in the different characteristics of high and low imagery words, rather than in methodologies used.

Paivio and Rowe(1971) conducted a study aimed at dealing with the findings of Rowe and Paivio (1971b), where it was reported that while high imagery word pairs led to better discrimination, meaning and frequency were, by in large, ineffective. Two explanations have been offered for the above finding. First, it could be that high imagery word pairs evoke more implicit associative responses (images) and differential image arousal would be responsible for the effect. This explanation would predict that verbal discrimination learning would be best for heterogeneous word pairs, with the high imagery item being the correct one. As an alternative, a S might "tag" an item as being right or wrong (relational interpretation). In this instance, it would be predicted that verbal discrimination learning should be best for homogeneous high imagery pairs. Results indicated that the only significant effect was that low imagery, homogeneous pairs were more difficult to discriminate. Therefore, the data appear inconsistant with either an associative, or a relational interpretation of verbal discrimination learning.

Rowe (1972) investigated imagery and repetition effects in verbal discrimination learning as a function of lag. It was argued that if imagery and frequency are truly independent variables in verbal discrimination learning, there should be differential effects of lag for the two variables. Subjects were presented two, 48 pair lists of high imagery words. On the first presentation, a pair appeared with the correct item being underlined, at lags of 0, 8, 16, 32, or 64 intervening items. Subjects were given instructions to: form an image to the item; verbally repeat the item; or were given no instructions at all. The results indicated that recall for the imagery group was superior to recall for the repetition group, which in turn was superior to the recall for the no instruction group. The main effect of lag was also significant, indicating that recall decreased, as lag increased. The effect of repetition on recall was interpreted as supporting frequency theory, while the overall superiority of the imagery group supports the contention of Paivio and Rowe (1971) that imagery instructions are more effective than repetition instructions in verbal discrimination learning.

While the focus of the research reviewed in the present paper has been primarily on the intentional use of imagery as an information processing strategy, still another area of investigation involving imaginal processes, has been in the area of incidental learning. An early investigation by Betts (1909) led to the conclusion that confusion in subjects increases the amount of reported imagery. The finding was later confirmed by the results of researches of Fox (1914) and Comstock (1921). Sheehan (1972) contends that the function of visual imagery in unexpected recall is an important area of study, in that much of the learning we engage in, is in situations where the demand for memory is unexpected.

Bower (1972) investigated whether the superior learning for imaginal instructions was dependent upon the subject's intention to learn. Subjects were given intentional or incidental learning instructions, with all subjects given an imagery orienting set at item inspection. Results (Bower, 1972) indicated similar levels of performance for the intentional and incidental groups, indicating that imagery instructions for the incidental group were quite sufficient to break down the typically reported inferiority of incidental learning, in comparison to intentional learning. Also, Yuille (1971) found that imagery (as defined by stimulis concreteness) was an influential factor in incidental learning. It was found, recall was better for concrete noun-digit pairs versus abstract noun-digit pairs, even though the subjects had been asked to name them, rather than learn them.

Yarmey and Ure (1971) investigated the effects of incidental learning, noun imagery, and direction of associations in paired-associate learning. Subjects were given one of four rating tasks on which to rate C-C, C-A, and A-A word pairs. Half the subjects were given intentional learning instructions and half were not. Following the inspection of word pairs, subjects in both the intentional and incidental groups were first given a free recall test, followed by a cued recall test. Results indicated that intentional recall was superior to incidental recall and that C-C pairs were recalled significantly better than the other pair types. Additionally, recall did not differ for C-A versus A-C pairs, and both C-A as well as A-C pairs were recalled significantly better than A-A pairs. Further, the effects of the direction of association was not significant, while being in the expected direction. It was concluded, (Yarmey & Ure, 1971), that intentional learning was quantitively better, but qualitatively similar to incidental learning.

It has been established that instructions to learn, which prompt clear expectation of recall, produce appropriate "representational responses" or "differential responses" during the inspection of the material to be learned. Further, it seems that a similar situation exists with respect to incidental learning, but to a lesser degree. Preexperimental habits which a subject may bring to a learning situation are many and varied. Included may be associative responses to inspection items, grouping and classification habits, imagery evocation, and selective reactions to various features of the inspection items. The amount of intentional or incidental learning which takes place is thought to depend on the representational responses brought to the experimental situation and on those representational responses aroused by the experimental situation. When recall occurs, it is these responses which must serve to facilitate memory. Further, it is thought that the responses occurring in the intentional versus the incidental situations may be different with respect to degree, rather than kind.

In line with this analysis, Sheehan (1972a) has hypothesized that the difference in amount recalled by intentional versus incidental learners will be a function of the imagery arousing value of the items in an inspection list. It was reasoned that, since imagery evocation occurs more readily for high imagery versus low imagery words, such responses should occur equally for intentional and incidental learners, for high imagery words. However, abstract words, not giving rise to imagery, should be easier to learn for intentional subjects, in that being motivated to learn the inspection items, they should produce additional non-imaginal representational responses. In summary, the hypothesis advanced by Sheehan (1972a) is as follows: the difference in recall for incidental versus intentional learning should be a function of the imagery value of the inspection items, the smaller the difference in recall between incidental and intentional learners.

In a test of the above hypothesis, Sheehan (1971a) used independent sets of subjects, that were given either incidental or intentional instruction in factorial combination with orienting task instructions to rate the inspection items for either, imagery value or familiarity. Inspection items consisted of both concrete and abstract nouns. Following the presentation of the inspection lists, a free recall test was administered followed by a recognition test and inquiry into the use of imagery mnemonics. It was predicted that, if imagery has functional significance in incidental learning, the difference in retention of the abstract and concrete words would be greater in incidental than in intentional learning. Results indicated that the hypothesis was supported only for the recognition test under the familiarity orienting set. It was suggested that the failure to confirm the hypothesis under the imagery orienting set, might have been due to the fact that this orienting set may have induced all subjects to make effective use of imagery for abstract words. In as much as the predicted effect was found in only one of four possible comparisons, the study was replicated (Sheehan, 1972) using only the familiarity orienting task. The results were consistant with previous results (Sheehan 1971a) in that, difference scores were again significantly larger for the incidental group, for only the recognition test.

A third study (Sheehan, 1971b) focused its attention on the relevance of inter-individual differences in imagery ability for the occurrance of the predicted effect (greater difference scores for recall of concrete versus abstract words for incidental learners versus intentional learners). Subjects were screened and classified into groups of high and low imagers. Half of each the high and low imagery subjects participated in the incidental condition, while the remaining half of each group of subjects were given intentional learning instructions. Once again, only the familiarity rating task was used for lists of high and low imagery words. It was predicted that more concrete than abstract stimuli would be recognized in the incidental than in the intentional learning condition for vivid imagers, while the predicted effect would not be evident for subjects with poor imagery ability. Additionally, it was predicted that, based on the findings of Ernest and Paivio (1971), the predicted effect should be more pronounced for high imagery females relative to high imagery males. The results of the study (Sheehan, 1971b) indicated that the predicted effect was confirmed for good imagers, but not for poor imagers. Also, results indicated that incidental learning effects were rare for high imagery males, while the larger difference scores were associated with high imagery females. This latter result can be taken as providing confirmation of the sex differences reported by Ernest and Paivio (1971).

Sheehan (1972a) has summarized the findings of the three researches just discussed. The findings have been taken to indicate that relatively more concrete nouns would be recognized in incidental learning as opposed to abstract nouns that would be recognized in intentional learning. Sheehan (1972a) stated that incidental and intentional learning may not represent two distinct processes, and the results may indicate that situations involving unexpected recall can benefit from visual imagery, to a greater extent, than those situations where it is known that recall will be required. It may be the case that incidental learning situations are such that one is not only at a loss over what to recall, but also, how to recall.

While it cannot be denied that imagery is an important variable with regard to verbal learning, there is some question as to the significance of imagery for the development and production of language. One of the major arguments against imagery mediated language production is the contention that words, by in large, are generic, while visual images are specific. Also, it has been argued that images are aroused too slowly to mediate language. Among the various arguments presented by proponents of imagery mediated language production are: it could be that images are schematic rather than specific; images need not be reportable to be functional; meaning may be variable rather than fixed; and finally, latencies for image formation may be faster than has been supposed in the past. The relationship between imagery and language has been defended by contending that meaning may be variable, rather than fixed (Paivio, 1971). It is assumed that the meaning process evoked by a word or other symbol is an organismic reaction with affective and/or motor and/or imaginal components, which may or may not be conscious. Further, Paivio (1971) assumes that the meaning reaction need not be fixed, but rather, that it may vary over time, dependent upon prior events and the situational context of the moment. Further, certain reactions to a symbol occur more readily than others, and it is these reactions which come to be called the "meaning" of a symbol. The organismic reactions may be thought of as a series of transformations or elaborations occurring at four discrete levels (e.g. iconic storage-no transformation; representational; referential-associative connections; associative-involves sequences of words or patterns). It is assumed that latency measures will reflect the availability of the above processes.

In line with the above, Ernest & Paivio (1971a) asked subjects to form images or verbal associations to high and low imagery words, presented tachistoscopically. Reaction times were collected by requiring the subjects to press a key upon the formation of an image or verbal association. It was expected that verbal associative reaction time should not differ for high versus low imagery words, while the reaction time for high imagery words should be substantially shorter than for low imagery words. Also, it was expected that, if the meaning of high imagery words is closely tied to imagery, both high and low imagery subjects should experience images to high imagery words, but high imagery subjects should be significantly faster with low imagery words. Results (Ernest & Paivio, 1971a) indicated that the major predictions were confirmed, and also, that high imagery subjects reacted faster than low imagery subjects to both types of words. The latter result was interpreted to indicate that verbal associations can also be mediated by imagery, and further, that the speed of higher order meaning reactions to verbal stimuli is more closely related to variables that define imagery processes than to those that define verbal processes.

However, Kintsch (1972) has reported that some differences in learning, that have been attributed to an imagery variable, could be due, in fact, to differences in lexical complexity. It was reported (Kintsch, 1972) that high imagery words tend to be lexically simple, while low imagery words tend to be lexically complex. Therefore, it was suggested that learning differences between high and low imagery words may be due to the number of transformations required to transform a given word into its root. Based on this reasoning, it would seem that the differences in reaction time to high and low imagery words, described by Ernest and Paivio (1971a) could be due to differences in the number of transformations which are required for the associative or imaginal reactions to the words.

Studies dealing with the relationship between imagery and language have also been extended to include the relationship between imagery and language comprehension. Paivio and Begg (1971), following a two process approach to cognition, reasoned that imagery should be an important component of associative meaning for concrete, but not necessarily abstract language. It was thought that the understanding of concrete sentences should be closely tied to intraverbal and associative meaning. Therefore, for concrete sentences, image latency should be approximately equal to comprehension latency. Subjects were shown concrete and abstract sentences, tachistoscopically, and asked to release a button (yielding a reaction time measure) upon formation of an image, or upon comprehending the sentence. The results indicated that latency differences for image formation and comprehension were markedly greater for abstract versus concrete sentences.

Also of interest has been research investigating the relationship between imagery and memory for connected discourse. It has been shown that, in paired associate learning, stimulus imagery is more important than response imagery. This fact has been interpreted as indicating that imagery is most important for retrieval of information. The dual coding model would hold that concrete sentences are likely to be encoded both visually and verbally, but would say nothing about differences in memory for concrete versus abstract sentences, in that encoding errors are possible. Paivio (1972) has hypothesized that imagery may either aid or hinder memory for language, dependent upon such factors as: the length of the units to be remembered; and the features to be remembered. Aiken (1971) had subjects study sentences (under imagery or no imagery instructions) with two nouns underlined, for 10 seconds. The subjects were told that a later recall test would require them to respond with one of the two underlined words. The underlined words were high imagery, high frequency nouns. Two recall tests were administrered, one immediate and another after two and one half hours. Results indicated that recall was better under imagery instructions than under memorization, for forward recall and dissimilar nouns. Additionally, meaningful similar nouns were more determental for imagery subjects, and imagery subjects showed less memorization of sentences. It was concluded (Aiken, 1971) that the results supported the contention that visual and verbal systems are independent. Sasson and Fraisse (1972) found that interpolated pictures or concrete sentences produced about the same amount of retroactive interference, in recall of sentences, in both immediate and delayed recall conditions. In a subsequent experiment, Sasson and Fraisse (1972) found that while memory for abstract sentences was not interfered with, by either interpolated pictures or interpolated concrete sentences, recall was impaired by interpolated abstract sentences. It was argued (Sasson & Fraisse, 1972) that these results indicated that abstract sentences are stored verbally, while concrete sentences are stored visually. These results could also be taken as being supportive of two major systems of memory.

Phillipchalk (1972) investigated the effects of thematicity and abstractness on the long term recall of connected discourse. Subjects were presented the words of a short passage (abstract or concrete), one word at a time. Half of the subjects were told that the words formed a short story, while the remaining subjects were told that the words were randomly drawn from the dictionary. Subjects were tested for recall of the words immediately following their presentation as well as after a two week delay. Results indicated that thematic presentation of the words resulted in better recall, for the concrete passages only, for both immediate and delayed recall. It was concluded (Phillipchalk, 1972) that concrete discourse has unique properties not possessed by either concrete or abstract material, presented randomly or by abstract discourse. It has been suggested that this property is the ability to generate a "surrogate structure", retaining the central theme of the passage, from which the passage may be reconstructed. In as much as the effect of thematicity appears to be limited to concrete discourse, could it be that the "surrogate structure" takes the form of some sort of interactive image? In any event, the effect of thematicity seems consistant with Paivio's (1971) statement, that the relationship between imagery and language can be altered by prior events and contextual considerations of the moment. Morris and Reid (1972) have also presented findings which seem consistant with the idea that the relationship between imagery and language may be situational. Subjects read a passage which contained either high or low imagery value adjectives. Later, the subjects were asked to recall as many nouns from the passage as they could, in a free recall test. It was found that the imagery value of the adjectives had no effect on the recall of nouns. The result was interpreted as indicating that nouns in prose material are affected by words other than just adjectives. If prose makes sense without the adjectives (subjects are able to generate a thematic structure) the addition of adjectives causes little change in recall. These findings seem consistant with Paivio's (1971) suggestion, that imagery may aid in the recall of a general theme, and some words, but not necessarily grammatical form.

Other research has investigated imagery versus deep structure in the memory for connected discourse. Rohrman (1968) has suggested that sentence recall is dependent upon the deep structure properties of the sentence. Paivio (1971b), however, has shown sentence recall to depend upon the imagery value of the sentence, while being independent of its deep structure. Subjects were shown lists of 20 high or low imagery nominalizations (10 subject and 10 object), and allowed three minutes for free recall. Results indicated that subject nominalizations were unaffected by imagery type, while high imagery object nominalizations were recalled significantly better than low imagery object nominalizations. There was no effect of nominalization type. Results were interpreted as being inconsistant with Rohrman's (1968) deep structure interpretations, while suggesting that imagery might be an important underlaying process. Also, correlations were computed between recall scores, for nominalization type and imagery type. It was found that, while nominalization imagery, participle imagery and noun imagery correlated significantly with recall, noun imagery correlated most highly. This was interpreted as suggesting that subjects needed only to recall the object image in order to reconstruct the "scene" described by the nominalization, as a whole.

Also, Danks and Sorce (1973), in a prompted recall task, varied the deep structure complexity and the imagery value of the prompt word (noun of the prepositional phrase) independently. It was found that full passive sentences were better recalled than passives with the agent replaced, and high imagery prompts were more effective than low imagery prompts. Syntax was effective for the low imagery condition and imagery was effective only in agent replaced sentences. The results were interpreted as indicating that, in the high imagery condition, syntax was negligible, in that the subjects could image the sentence, while for the low imagery condition, syntax was effective, in that an image was not readily available. The results of Danks and Sorce (1973) seem consistant with results reported by Paivio (1971b), that a subject only needs to image the object referent in order to reconstruct the scene. This suggests that passive sentences may be transformed into their declarative counterparts prior to processing.

Paivio (1971a) contends that the major implication of the imagery approach to language, is that the acquistion of language may depend, initially on imagery. That is to say, initially, an infant's knowledge about the world is stored in the form of images. Eventually, language becomes connected to the image foundation, remaining intertwined with it, but developing a certain degree of autonomy. Syntax is also thought to develop from an imagery substrate. As the child sees objects interact, the relationships tend to repeat themselves, and eventually a sort of syntax is built in to the imaginal representations. Then at a later stage, the child learns to label the objects and the existing relations between them. Recent findings by Moser and Bergman (1973) seems consistant with the above position. Subjects learned an artificial language, by means of sentences presented alone, or by means of sentences and pictures depicting the meaning of the sentences. Learning occurred more rapidly for the sentences plus pictures condition. Further, syntax learning did occur in the above condition, but did not occur in the sentences alone condition. Also, class membership of new words could then be learned by the sentences plus pictures condition, in a strictly verbal context, which was sometimes mediated by imagery.

Having reviewed the recent literature with respect to research dealing with imagery, what conclusions can be drawn? The classical notion of visual imagery has been attacked and evidence presented (Neisser & Kerr, 1973) that visual imagery is something other than a "mental picture". However, the dissenters from the classical conception of imagery (Pylyshyn, 1973; Neisser, 1972) admit to the spatiality of the imagery process, while denying that said spatiality is necessarily fundamental. Such a concession, in light of existing empirical evidence (Atwood, 1971; Kosslyn, 1973), seems necessary. In any event, whatever the fundamental nature of imagery might be, it does appear to possess some sort of spatiality.

When considering the function of imagery, however, the issues seem somewhat less resolved. It would seem safe to conclude that imagery represents a major system for human information processing, that is in general, facilitative. Further, the research investigating the effects of imagery in relation to incidental learning would seem to indicate that imagery does not depend on motivational factors, in exerting its influence, nor does imagery depend on conscious awareness. The question, as to the root of the imagery effect being due to differential intraverbal interference, however, is unresolved. Research on bizarreness and interacting images has led to inconsistant, and sometimes conflicting results. In this case, it might be wise to take note of the notion that imagery may function differently, in different tasks, and closely examine the methodologies used in bizarreness and interacting imagery research. Further, results presented by Paivio and Foth (1970) appear to rule out ease of encoding as an adequate explanation of the imagery effect. Therefore, while imagery can be said to represent a major system for human information processing which has spatial properties, and does not depend on conscious awareness or motivational factors, the question still remains as to how imagery exerts its effect (chunking, ease of encoding, reduction of interverbal interference). Hopefully, a better understanding as to the function and nature of imagery, will result in a better understanding as to how the human being copes with information in his everyday world.

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