PERCEPTUAL INDEPENDENCE-DEPENDENCE: ON THE LOCALIZATION AND IDENTIFICATION OF ITEMS IN TWO-DIMENSIONAL SPACE

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ABSTRACT

Tachistoscopic studies concerned with the information processing approach to perception have generally used alpha-numeric stimuli. The criterion of information processed is usually some measure of Ss capacity to identify. Other dimensions of stimulus information, in reference to iconic storage, encoding, and short-term memory have received little attention. Three experiments were performed which examined the processing of position in 2-dimensional space and identity information, involving; (a) the probe technique, where iconic decay was studied; (b) masking procedure, where rate of encoding was investigated; and (c) tachistoscopic short-term memory, where memory span and the effect of exposure duration was examined. In addition, each experiment was designed to determine whether position and identity information was processed independently, by means of performance parity.

The probe experiment, demonstrated comparable rates of decay, of positional and identity information. However, positional information gained more benefit from procedure of partial report, than identity information. S's reports, or

scores, revealed a loss of parity or interaction when both position and identity information was stored in visual storage. The interaction was attributed to an inverse relationship between structural complexity of the stimulus and clarity of iconic storage.

The main results of the backward masking experiment are: (a) a loss of parity, when both position and identity information had to be encoded; (b) the rate of encoding of positional (identity) information was independent of whether position (identity) was processed singly or in combination with identity (position); and (c) the rates of encoding of the two types of information were significantly different. The results were interpreted by appeal to the microgenetic point of view, and the possibility of different encoding mechanisms, for position and identity information.

Finally, the short-term memory experiment demonstrated an interaction between the storage of position and identity information. Exposure duration (30 - 90 msec.), had no effect on storage capacity.

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STATEMENT OF THE PROBLEM

Neisser (1967) defines cognition as "... the process by which the sensory input is transformed, reduced, elaborated, stored, recovered and used." Within this context a number of investigations have been concerned with the transformation and storage of sensory input presented tachistoscopically. One such line of research using alpha-numeric materials has resulted in a suggested model involving (1) brief visual storage in the form of an image or icon which persists for some brief period of time after the stimulus has been removed, (2) an encoding or noting process which transfers the information in visual storage to (3) a secondary storage or short-term memory system (e.g., Averbach & Coriell, 1961; Averbach & Sperling, 1961; Eriksen & Spencer, 1969; Haber & Standing, 1968; Keele & Chase, 1967; Mackworth, 1962, 1963; Massa, 1967; Sperling, 1960, 1963, 1967; Von Wright, 1968).

Sperling (1960, 1963, 1967) devised techniques by which he was able to demonstrate that more information is available in visual storage than the subject is able to report. He demonstrated, as well, that the effective duration of visual storage is generally one second or less. Since the report of the subject is not complete until several seconds after the stimulus has been removed, it dictates the necessity for assuming the existence of a secondary storage of longer duration. The transfer of information from visual storage to secondary storage requires an encoding process.

Research, in this area, related to the above model, has been conducted with alpha-numeric stimulus materials where the criterion measure of information processed is defined as items correctly identified. The stimulus materials, however, also contains other forms of information, such as position of items. It is the purpose of the present project to investigate the information processing characteristics of position, as well as identity, within the Sperling framework.

Although some investigations have been concerned with the correct positioning of identified items (e.g., Sperling, 1960; Liss, 1968), the stimulus materials have been of such nature (e.g., regular arrays, such as two rows of four letters), where processing of position information cannot be examined independently from, and in conjunction with, identity processing. In order to secure data relevant to this problem, a basic requirement is to have a grid with fewer items, than spaces. With such stimulus materials, the proper localization, as well as the proper identification, of items can be investigated singly or jointly.

Once independent scores are secured for the processing of position and identity, answers become available which cannot be secured otherwise. For instance, does the icon preserve one kind of information -- position or identity -- for longer periods of time than the other? Are the rates of encoding different for the two kinds of information? Does the processing of both kinds of information interact or proceed in an independent fashion? If there is interaction between the processing of positional information and identity information, what is the possible nature of the interaction? By using such techniques as employed in the probe, masking and tachistoscopic memory span studies, on the type of stimulus materials earlier specified, the present experimental program is designed to provide evidence that will bear upon the above questions.

INTRODUCTION

As has been indicated, such authors as Averbach & Coriell (1961); Eriksen & Collins (1967); Keele & Chase (1967); Mackworth (1962, 1963) and Sperling (1960, 1963, 1967), to name only a some, have amply demonstrated that visual stimulation is initially stored in some sensory or visual store. Information from this relatively isomorphic representation of the stimulus is then encoded in some manner and then stored in some type of short-term memory system. Although there is a relatively high degree of agreement about the general conceptual model as outlined above, this is not the case when the various sub-processes are considered in detail. The purpose of this section is to examine in some detail, the nature of visual storage, the encoding process and short-term memory as has been developed in the literature. Moreover, a major concern will be how these processes or mechanisms may operate in the perception of position in 2-dimensional visual space.

Visual Storage

The concept that a visual representation of a stimulus will outlast the presence of the stimulus has been around for sometime. For instance, Allen (1926), in a review of visual persistence, notes that the first recorded observation of visual persistence, goes back to the fifth century, A.D. The first measurement of the duration of visual persistence was attempted in the 18th century. Quoting Allen (1926):

> "Measurement was made by him [Seigner-1740]* to determine the time factor of persistence of vision. He concluded that when a glowing coal is given the precise velocity sufficient to complete the luminous circle, the duration of the sensation is then equal to the number of revolutions of the coal. He found this to be about one-half of a second, but in order to be on the safe side he decided to adopt the value of 1/10 of a second." (p.488).

As can be seen, the concept of visual persistence is by no means new. Brief historical notes may be found in Sperling (1960), and Neisser (1967). Renewed interest in this area, however, stems from Sperling's (1960) monograph. The reason for this is that Sperling introduced a new experimental technique to demonstrate the existence of visual storage and to measure the rate at which visual storage decays. The nature of this technique -- the probe or partial report -- can best be illustrated by directly quoting Sperling (1963).

> "Subjects were presented stimuli consisting of twelve letters and numbers in three rows of four symbols each. The exposure duration was 50 msec. The stimulus exposure was immediately followed by a tonal signal. The subjects had been told to report only one row of letters, and the signal indicated to the subject the particular row to be reported. Subjects were able to report correctly 76% of the

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*Brackets and name inserted by this author.

> called for letters even though they did not know in advance which particular row would be called for. This result indicates that after termination of the exposure, subjects still had available ... 76% of the 12 symbols, that is, the 9.1 symbols. However, when the tonal signal was delayed for only one second, the accuracy of report dropped precipitously from 76 to 36%. Note that 36% of 12 symbols is 4.3 symbols; the previously established memory span for this material was also 4.3 symbols." (pp.20-21).

The above description of the probe technique demonstrates two facts: (1) initially much more information is available to S immediately after stimulus presentation, than can be recalled, and (2) this larger amount of information is available only for a short period of time. The concept of, what has been variously termed, visual persistence, visual storage, visual image, visual memory, icon (Neisser, 1967), or sensory register (Atkinson & Shiffrin, 1968), appears to account most readily for these facts. This is supported by the fact that under stimulus presentations favoring visual persistence such as pre- and post- dark exposure fields, performance on the probe technique decays much slower as a function of time than when pre- and post- exposure fields are light.

Keele & Chase (1967) provide further evidence for the visual nature of the iconic storage system. They found that errors in data obtained from the probe technique correlated significantly with structural similarity of the letters. A similar finding was not obtained when errors were correlated with an auditory confusion matrix. Since Conrad (1964, 1965, 1967) has demonstrated that auditory confusion is an important source of errors in recall of letters from short-term memory, it may be assumed that the probe acts upon a visual storage system and not a secondary or short-term memory system.

From the above mentioned lines of evidence, it can thus be assumed that a briefly presented visual stimulus leads to a relatively isomorphic visual representation of that stimulus, persisting for sometime after the cessation of the stimulus. Thus, such a neural representation of the stimulus supposedly contains such information as form, location, number, and so on.

Generally, most authors (e.g., Haber & Standing, 1968; Neisser, 1967; Sperling, 1960, 1963, 1967), have assumed that visual storage lasts long enough so that information may be extracted and stored elsewhere. Duration of iconic storage is estimated to be approximately ½ second under normal lighting conditions. The recall and reporting of letters requires an appreciably longer time than duration of visual storage. This, then, points to the need of the short-term memory process and presumably an encoding process which transfers information from iconic storage to short-term memory.

Granted that information is stored in visual storage for subsequent extraction, such questions arise as to whether the decay rate of identity and locations are the same or different. One might expect that the relatively complex form required for the perception of identity might decay leaving random elements still sufficiently clear to specify position. One of the experiments in this project will examine the above and other considerations in further detail.

The Encoding or Noting Process

After a stimulus is registered in some kind of sensory storage, such as iconic storage or visual storage, information must then somehow be transformed into a primary memory, or short-term memory storage system. This transformation is often referred to as encoding and the speed with which this process takes place -- the rate of encoding. Work in this area has centered around two important questions, which are: (1) What is the rate of encoding, and (2) Is the encoding process a serial or parallel process? (e.g, See Eriksen & Spencer, (1969) for review). Despite a large amount of experimental work there are no clear cut answers to these questions, to date. However, the present section will concern itself with the rate of encoding and will attempt to evaluate whether or not there is a means of measuring the rate of encoding either in absolute or relative terms. The purpose of such an attempt, is to determine whether or not it is possible to investigate the rate of encoding of, (1) the locations in 2-dimensional space, and (2) the identity of alpha-numeric material.

Sperling (1963, 1967), in an attempt to determine the rate of encoding of letters and digits from visual storage used a backward masking procedure, in an effort to control the duration of visual storage. The backward masking stimulus consisted of randomly placed letter fragments (visual noise). Sperling felt that the backward masking stimulus really had no backward effect. When the backward masking stimulus is established as a visual image shortly after the establishment of the image of the first or target stimulus, the backward masking stimulus erases the target stimulus. The backward masking stimulus in effect, cuts short the time needed for the encoding of information from visual storage, to a more permanent memory store and hence, the interference with the perception of identity, or, with recognition of the target stimulus.

Sperling (1963, 1967) provides compelling evidence for his interpretation of backward masking by visual noise, First, he found that the number of letters perceived was a linear function of the stimulus exposure time prior to masking, (stimulus onset asynchrony), up to a limit of memory span. Sperling (1963, 1967) found that the rate of encoding was approximately one letter per 10 msec.

As important as the above finding, the number of items reported was independent of the number of items presented. Liss (1968) obtained a similar result under similar experimental conditions. Averbach (1963) also obtained similar results in determining the span of apprehension of dots, i.e., the number of dots, as a function of stimulus onset asynchrony. The above results strongly suggest that the encoding of information from visual storage is sequential in nature and that a masking procedure can be used to measure the rate of encoding.

However, Sperling's position on backward masking by visual noise has been critized by several investigators, (e.g., Eriksen & Hoffman, 1963; Eriksen & Steffy, 1964; Kahneman, 1966; Kinsbourne & Warrington, 1962a, 1962b). These authors feel that Sperling's results can be as adequately explained by the fact that a backward masking stimulus degrades the target stimulus. Thus, the basic finding, that the number of letters reported increases as a direct function of stimulus onset asynchrony would stem from the fact that there exists a concommitant increase in clarity of visual storage and target stimulus. Rather than an 'erasure' point of view of the effect of a backward masking stimulus, these authors hold to a temporal summation point of view (e.g., Eriksen & Hoffman, 1963). Or, in other words, the backward masking stimulus summates with the target stimulus so as to make perception of the target more difficult, (Eriksen, 1966; Eriksen & Lappin, 1964).

It should be pointed out, that if such a summation point of view is correct, then backward masking can hardly be used as a tool in ferreting out temporal factors in visual information processing. Thus, S under backward masking conditions reports less information, not because he has less time to process whatever information there is in the icon, but simply because the icon is degraded or contains less encodable information. That such summation does occur when a bright light is used as a backward masking stimulus has been demonstrated by Eriksen & Hoffman (1963), and Eriksen & Steffy, (1964). It is difficult to see, however, how backward masking by visual noise simply degrades the icon. The many contours in such a backward masking stimulus, once superimposed on the icon of the target stimulus, would not only degrade the existing icon, but should make any further encoding of shape (letters) impossible.

Aside from the above consideration, two recent experiments have produced evidence contrary to a degradation or summation hypothesis, (Haber & Standing, 1968; Liss, 1968). Quoting from Haber & Standing (1968);

> "Three Ss viewed arrays of four letters which were either varied in duration or followed by visual noise. On half of the trials they rated the clarity of letters; on the other half they attempted to

> recognize all of the letters. The results showed that while both clarity and recognition increases in parallel as duration was increased, clarity exceeded recognition accuracy when visual noise followed the array. Thus, Ss said the letters were clear even though they did not have enough time to process them." (p.83).

In an almost identical experiment by Liss (1968), similar results were found. In addition to this, Liss (1968) also confirmed Sperling's other finding, that the number of letters correctly identified under backward masking conditions is essentially independent of the number of letters presented. Moveover, this independence was not the case where the letters were simply degraded -- e.g., short duration exposure.

Neisser (1967) maintains yet another view of backward masking. Aside from maintaining a degradation point of view, he also states that the effect of the mask may be delayed. How this delay comes about is not clear, but the postulate is a necessary one, in as much as Neisser (1967) believes that the rate of information transfer from iconic storage to short-term memory is about one item per 100 msec. This estimate is based on 'rates of counting' procedures (e.g., Landauer, 1962). It is difficult to see, though, how for every additional 10 msec. delay in the onset of the mask, an additional 100 msec. of processing time will result.

In summary, to this point, it may be stated that whatever the precise influence a backward masking stimulus has on a target stimulus, it does shorten the available processing time for the target stimulus. Experiments on clarity ratings by Liss (1963), and Haber & Standing (1968), demonstrate that some degradation of the target stimulus occurs because of the backward masking stimulus, but these studies also point out the fact that the clarity increases faster under backward masking conditions than under degradation alone, as a function of the number of letters correctly reported. In addition, Neisser's (1967) point of view that the backward masking stimulus must be delayed somewhat, also does not argue against the fact that backward masking stimulus shortens duration of visual storage of the target stimulus. Thus, Sperling's measure of the rate of encoding, perhaps not accurate in absolute terms, may serve as a relative index of the rate of encoding. The relative rate of encoding can be used in evaluating the order and interaction of such aspects of stimulus information processing, as position and identity, of letters.

One other point should be noted, especially when more than one type of information is to be transferred from visual storage under masking conditions. That is, at least at relatively brief stimulus onset asynchronies, masking may well interfere or be sensitive to the development of the image (Lindsley, 1961; Lindsley & Emmons, 1958; von Noorden & Burian, 1960). That iconic storage or an image must be constructed or developed has been discussed by such authors as Neisser (1967) and especially by the proponents of the microgenetic point of view, (e.g., Flavell & Dragnus, 1957; Kaswan, 1958; Kaswan & Young, 1963). This leads to the possibility that different types of information, within a particular target stimulus, have different functional processing or encoding times.

One of the experiments in this project will address itself to the above considerations (e.g., Does encoding of position and identity information occur independently?), and the same and other considerations will be examined in greater detail. However, it should be mentioned at this point, that Liss (1968) briefly noted, "... that for some S̲s backward masking increases the normally negligible tendency for letters to be correctly identified but placed in the wrong position." This result, is suggestive of a process where identification occurs before positioning, or perhaps, that the relative rate of encoding of position is slower than the relative rate of encoding of letters or identity.

Short-Term Memory

Several studies and reviews, have indicated that verbal material, such as letters, digits and words, if presented visually, are stored auditorily (e.g., Conrad, 1963, 1964; Conrad & Hull, 1965; Neisser, 1967; Sperling, 1963, 1967). For instance, Conrad (1964) found that the substitution errors made in recalling visually presented letters were just like those made in identifying letters spoken in a noisy background. This strongly suggests that letters encoded from visual storage are then stored in some auditory storage system. This is not to imply that the letters themselves do not maintain some structural trace or visual code.

Assuming that verbal material is generally stored auditorily, the question remains as to how localization of letters or points in 2-dimensional space are stored in short-term memory. If items form a regular array such as a row of six letters, then very possibly, locale or position of letter may be mediated by a temporal factor, such as, order of entry into short-term memory (if encoding is sequential). Even if such is the case, this would not be likely, if points in space were randomly organized. A verbal or auditory storage mechanism is not likely to be of service in this situation. More likely, a secondary visual storage of some type or a "visual code" (Posner, 1967; Posner & Konick, 1966), is responsible for the more permanent retention of position. This is not to imply that the secondary visual storage system is phenomenally visual in nature. For this reason, it will be referred to as a visual code, after Posner (1967), who makes this distinction.

If it is assumed that position of items and their identity in the case of alpha-numeric material are stored in separate short-term memory systems then the question arises as to how the information from these two visual systems is integrated into a correct response. Sternberg (1969) has suggested that auditory representation of a letter can generate a visual representation or visual code. Posner, Boies, Eichelman & Taylor (1969), provide a test for this hypothesis. Posner & Keele (1967), Posner, Boies, et.al. (1969) have demonstrated that the "same" reaction times are faster when two letters are physically identical (e.g., AA), than when they have the same name (e.g., aA). The authors attributed this to the fact that in the physical match, Ss can match on the basis of a visual code, whereas, in the identity match, an additional encoding procedure -- naming -- must take place. The interesting result of the Posner, Boies, et.al (1969) report, is that under appropriate instructions, if the first letter of a pair was presented orally and the second letter visually, the reaction time was as efficient as a physical match. This evidence strongly favors the hypothesis that auditory information can generate a visual code, which is then utilized in a matching process.

Thus, if it is assumed that position and identity are stored in different short-term memory systems, a matching process between these two systems could possibly account for correctly identified letters in correct position responses (P x I). Identity, it is assumed, will be encoded from visual storage and stored in some auditory short-term memory system. The structure of the stimulus array, or rather visual storage, will be encoded or tranformed into some short-term memory visual code. The auditory representations of the letters are capable of generating visual codes which are then matched into the overall visual code or visual short-term memory.

However, since this model also assumes joint storage of position and identity in the visual code, it is possible that a matching process is not necessary. Thus, correct P x I responses, may be directly retrieved from the visual code or visual short-term memory. Should such be the case, then an auditory transformation of visually presented verbal material may not be a necessary condition.

In considering short-term memory, the nature of rehearsal must also be noted. Whereas, the rehearsal process with verbal materials in auditory mode of storage has been well documented, this has not been the case with a visual short-term memory system (Atkinson & Shiffrin, 1968). It may well be, that the remembering of both position and identity of an item in 2-dimensional space, places a much greater demand on the rehearsal capacity of the S. If this rehearsal capacity is verbal in nature, remembering the place and identity of an item requires the sort of interaction or transformation between visual and auditory short-term memory, discussed above.

Perhaps, at this stage, it is too speculative to talk of a visual and auditory short-term memory as if they were separate storage systems. Just as a "visual code" is not visual in nature, an "auditory code" does not have to be aural in nature. In fact, the visual code and auditory code may be the one and the same code which can assume expression in a dominant dimension, depending on the nature of the stimulus material, task requirement in the case of recall, individual, and so on.

Certainly, a stimulus has or may have both visual and aural characteristics. Conrad (1964) and others, have demonstrated the fact that a visually presented array of letters displays aural characteristics in short-term memory. On the other hand, Posner, Boies, et.al. (1969) have demonstrated that an aurally presented stimulus can be transformed into a visual code. Thus, it may well be that the most parsimonious interpretation involves a notion of a short-term memory code which can assume different sensory-response dimensions, as the need may be (Tversky, 1969).

The effort of the present experimental program will not be directly concerned with determining whether or not position and identity, when processed simultaneously, are stored in spearate short-term memory systems. Rather, the main concern, will be whether or not position and identity, are processed in a dependent or independent fashion, when they are presented to S singly or in combination. However, certain aspects of the data will possibly have interpretive value in reference to the nature of short-term memory storage process, as discussed in this section.

A FURTHER STATEMENT OF THE PROBLEM

The above sections in the Introduction have delineated the general information processing model, within which framework the present investigations will be carried out. The characteristics of the experiments which have developed the model and which have posed the general problem to be investigated here, are that at least two types of information -- position and identity of items -- are present in the stimulus material. Several questions suggest themselves with respect to the processing of these two types of information. For instance, Does the icon preserve one kind of information for a longer period of time than the other kind of information? Are the rates of encoding the same or different for the two types of information? When both types of information are processed together, does it occur in a dependent or independent fashion and at what levels of information processing -- iconic storage, encoding process or short-term memory -- does the dependency or independency occur?

The last problem, in reference to dependence-independence, deserves some further comment. To avoid confusion, the words independent and dependent refer to the processing characteristics of whatever mechanism(s) is involved in the mediation of information from stimulus to completion of response. The criterion of independence will be performance parity. Thus, if identity and position performance is unaffected when the two kinds of information are processed, singly or in combination (parity), then whatever mechanism(s) is responsible for the processing of such information can be said to operate in an independent manner. Conversely, if there is a loss of parity when both types of information must be processed, then some form of interaction can be said to exist. Whether or not the types of information are processed jointly by one mechanism or separately by different mechanisms, is another question. Either a single or separate mechanism can operate in such a way where they lead to independent or dependent conclusions, as stated above. However, inferences can be made about joint or separate mechanisms, by studying the rate and amount of information processed. Thus, for instance, if it is found that the rate of encoding for identity is different than the rate of encoding for position, the conclusion that separate encoding mechanisms are operating, is indicated.

As noted earlier, past experiments do not permit obtaining separate scores or independent measures of identity and position processing. To make this possible an incompletely filled grid must be used so that position performance can be evaluated independently from and in conjunction with identity performance. Such a grid may consist, for example, of a 6 x 4 matrix containing eight randomly placed items.

If the grid contains randomly placed letters (P x I stimulus material) one set of instructions may require S, after exposure, to report both the position and identity of letters (P x I task) by placing letters on a response sheet containing a blank matrix. Amongst other measures, one can score positions correctly reported, irrespective of their letter content (p score) and letters correctly identified irrespective of their reported location (i score). Another procedure will consist of presenting S with stimuli such as grids containing randomly positioned O's or stimuli containing regular arrays of letters. In this case, S may be asked simply to report positions (P performance) or letters (I performance).* A performance parity check between p score and P performance and between i score and I performance will indicate independence in the case of parity or some form of interaction in the case of loss of parity.

Should the above comparisons indicate a loss of parity and hence some form of interaction, the interaction could be localized in processes at the 'perceptual end' or in processes at the 'response end' or indeed in any of the

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*The different measures as indicated above need be named. Since no suitable nomenclature is available, abbreviations will be introduced in text as required. In view of the unfortunate fact that this will lead to a profusion of abbreviations, a page of the abbreviations and their meanings will be incorperated at various points in the text to make the readers' task somewhat easier.

FREQUENT ABBREVIATIONS

Stimulus Material	Task	Score
P x I cards A matrix containing randomly placed letters, fewer than the number of matrix cells.	**P x I task** Reporting both the identity and the matrix position of letters.	**P x I score** The nunber of correctly identified letters in their appropriate position.
		p score The number of correct positions indicated irrespective of identity in P x I task.
		i score The number of correct letters reported irrespective of position in the P x I task.
		P + I score Any correct letter position. (Includes P x I score).
	PX task Reporting only position when P x I cards are presented	PX score Number of positions correctly reported.
	XI task Reporting only letters when P x I cards are presented.	XI score Number of letters correctly reported.
P cards A matrix containing O's	P task Reporting position.	P score Number of positions correctly reported.
I cards Regular array of letters.	I task Reporting letters.	I score Number of letters correctly reported.

intervening stages of information processing. For instance, an interaction could result from the fact that S must respond on both dimensions of stimulus information. In other words, positioning and identifying letters may not be fully compatible responses. In order to aid the specification of the nature and locus of interaction, in case of loss of parity, a third set of measurements will be considered. These measures will be derived from a procedure where S is presented with a grid containing randomly positioned letters but is required to respond selectively to one stimulus dimension, either position or identity (PX, XI, task). To the extent that S must process the irrelevant stimulus dimension (Broadbent, 1958; Treisman, 1964a, 1964b), the P x I task and PX task (XI task) are perceptually the same but require different responses from S. That is, in the case of the P x I task, S must report on both dimensions of stimulus information, whereas, in the PX or XI task, S reports only one dimension. Again, to the extent that S processes the irrelevant stimulus dimension in the PX task (XI task), this task is perceptually different from the P task (I task), but requires identical responses from S. That is, in the case of the P task or I task the stimulus materials, unlike the P x I stimulus materials, contain only one dimension such as a grid partially filled with O's or a regular array of letters and like the PX or XI task, S is required to report on only one stimulus dimension.

As has been mentioned, the above procedures will be applied under experimental conditions presumably sensitive to visual persistence, rate of encoding and short-term memory. By means of careful interpretation of experimental results, it is hoped that a more detailed specification of the information processing model, as developed by Sperling (1963, 1967) can be deduced. The data from which such various deductions are made are, of course, S's reports (scores) achieved under various conditions and these obviously, may be affected at any, or all stages, of the assumed cognitive processes. There will, therefore, be a need to look at the relations between sets of data derived from different experimental conditions. For example, decay rates in visual storage may be different for positional and identity information, but because of possible differential encoding rates these decay rates may not be reflected in Ss scores. Thus, it is hoped that by these convergent operations, the processing of position and identity information can be specified to some extent. (See Haber, 1969 for discussion on convergent operations). This, of course, means that the same Ss will be observed, not only on the several measures within an experimental technique, but also across the different experimental techniques.

EXPERIMENTAL INVESTIGATIONS

The general model that has been developed to explain performance on the tachistoscopic tasks, using alpha-numeric materials, involves the processing of information in terms of visual storage which is then encoded and transformed to a short-term memory system or storage. As has been indicated, the experiments which follow, employ stimulus materials of such a nature, that independent measures of positioning and identification, as well as a measure of correctly identified items appropriately localized, can be obtained.

Accepting the model (e.g., visual storage-encoding -short-terms memory) as a general framework within which to evaluate various information processing characteristics, a logical experimental sequence suggests itself. The sequence of experimental investigations like the Introduction will follow the temporal order of information processing. Thus, Experiment 1 will deal with the characteristics of visual storage. The probe technique, will be used to estimate the rates of decay for the different types of information. Thus, specifically, an attempt will be made to ascertain whether different types of information are stored dependently or independently in visual storage, and whether or not positional information continues to be retrievable from iconic storage after identity information has decayed.

The second experiment, will be concerned with the encoding process. The purpose here, is to determine the relative rates of encoding for the different types of information. Again, an effort will be made to determine whether or not encoding of the two types of information occurs in a dependent fashion. The results will, of course, be related to the first experiment, as well as the experiment to follow.

The third experiment, will deal with the capacity of the short-term memory system. Data will be used as a reference point against which masking performance can be evaluated. Specifically, an attempt will be made to determine whether or not storage of position and identity occurs in an independent or dependent fashion.

The organization of the remainder of this section then will consist of the three experiments as has been outlined. Each experiment will have an introduction relevant to its specific purpose. Also, a brief discussion will follow each experiment, but the major discussion will follow this section.

EXPERIMENT ONE

VISUAL STORAGE AND DECAY FUNCTIONS FOR POSITION AND IDENTITY

By the use of the probe technique, it has been demonstrated that the visual image persists for sometime after removal of the stimulus (e.g., Mackworth, 1962, 1963; Sperling, 1960; Turvey, 1967). The work in this field has been primarily concerned with the task of identification. Here, the concern is with position and identity.

Three areas of consideration comprise the focus of the present experiment. First, it remains to be demonstrated that the probe technique will be functional when dealing with stimulus material where items are randomly distributed in 2-dimensional space. It may well be that the added complexity of random locations will confound or obscure the partial reports sensitivity to a visual decay factor.*

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*It should be noted that a preliminary investigation failed to demonstrate any advantage of partial report over whole report. Stimulus materials consisted of a set of 6 x 4 matrices, each containing eight randomly placed letters with the restriction that four letters were placed in the left and right halves of the matrix. Ss had to report the contents -- letters, positions, or both -- of half the matrix, using a visual cue at various probe delay times. The experiment was repeated with similar sets of stimulus materials so constructed as to allow (a) report of top and bottom halves of the matrix, and (b) left, right or center two columns of the matrix. Failure to obtain a partial report effect was attributed to the fact that

On the assumption that the probe technique will yield an indication of decay of positional and identity information, the second area of concern centers around the degree of decay of positional versus identity information. For instance, if a letter is used to specify location in 2-dimensional space, it is possible that the letter itself may be decayed (in visual storage) to an unidentifiable shape while still serving to indicate position. Thus, it would be reasonable to expect that the degree of visual decay will be larger for identity than for positional information.

The third topic of major interest in the present study stems around the concept of perceptual dependence-independence. Dependence-independence will be determined by means of parity comparisons between the different tasks. Or, as has been stated earlier, a comparison will be made between (a) tasks that are perceptually different but not instructionally so (PX - P comparison and XI - I comparison) and (b) tasks that are instructionally different, but not perceptually different (p - PX comparison and i - XI comp-

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*Footnote - continued from page 28 -

S, although capable of selecting information according to various structural attributes (Clark, 1969; Dick, 1969; Turvey & Kravetz, 1970; Von Wright, 1968) from iconic storage, is not capable of manipulating the structure of the content of visual storage (Atkinson & Shiffrin, 1968). It is for this reason, stimulus materials were constructed as described in text. (See Illustration 1).

arison).

SUBJECTS: Six paid volunteers -- all male -- served in this and subsequent experiments. Although all Ss were naive in regards to the purpose of this and subsequent experiments, they must be viewed as well practiced, sophisticated observers. If practice sessions are included, each S served in well over thirty experimental sessions of approximately one hour each. All Ss had normal vision. Ss ranged from 20-24 years in age with a mean of 22 years.

APPARATUS: A Scientific Prototype, Model GB, three channel tachistoscope, containing original (new) lamps, was used.

STIMULUS MATERIALS: Three different sets of stimulus cards were constructed. All three sets used letters from Letraset Printpak No. 6 and white index cards. An example of each type of stimulus material may be seen in Illustrations 1, 2 and 3. The specification of each set of stimulus cards is as follows:

a). P x I cards, or cards containing randomly positioned letters. Stimulus cards consisted of three 2 x 4 matrices placed in a row. Each 2 x 4 matrix contained three randomly chosen letters from a set of 21 letters. Excepting the Y, vowels were not used. The following restrictions were placed in constructing the distribution of letters in the 2 x 4 matrix; (1) each letter within a particular 2 x 4 matrix was used only once; (2) all 21 letters within a set of matrices occupied each of the eight matrix cells once and only once. The total number of matrices necessary to satisfy requirement (1) and (2), is 56, and such a number of matrices were generated. Fifty-six stimulus cards were then constructed by randomly choosing three such matrices for each card with the restrictions; (a) no matrix was used more than once on a particular card, and (b) over the entire set of stimulus cards 56 different 2 x 4 matrices occupied a particular position, i.e., left, right or middle position. The size of a cell matrix was approximately 0.74° x 0.74° and the separation between the three matrices was about 0.45°. (See Appendix A, for listing of probe stimulus materials).

b). <u>P cards</u>, or cards containing position information only. The stimulus cards are identical to the P x I cards, except that all letters were replaced by O's, again yielding 56 cards.

c). <u>I cards</u>, or cards containing letters and no random positions. Letters from each card in P x I were simply arranged in three columns of three -- again yielding 56 cards. Separation between columns was approximately 2.11° and rows 0.90°. Thus, the letters were so spaced as to approximate the separation between letters in the P x I stimulus cards.

The probe consisted of two vertical back-lighted slits 0.15° x 0.75° in dimension, falling above and below any particular matrix or column of letters. Separation between outer boundary of stimulus material and slit was 1°, if superimposed. Luminance of stimulus presentations was set at approximately 20 ft. L.

PROCEDURE: The procedure consisted of five different tasks as a function of the three different sets of stimulus cards. Stimulus cards under all conditions were exposed for 60 msec.* The probe that directed S to report the left, right or middle stimulus material came on at 0, 100, 250, 450 and 700 msec. after cessation of stimulus exposure. The probe itself had a duration of 150 msec. The different tasks and procedures involved are as follows:

P x I Stimulus Cards: The procedure consisted of three distinct tasks for all Ss. They are, (a) localizations of positions, ignoring identity of letters (PX task), (b) identification of letters ignoring position (XI task), and (c) correctly identifying letters and their positions (P x I task). Ss had blank grids in front of them identical to the matrices on the stimulus cards. Thus, if the probe indicated the center matrix, S was to report on the information of the center matrix. In the case of the PX task, the Ss were to mark those cells, using numbers 1 through to 3, where they thought

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*A 50 msec. exposure was planned originally, keeping more in line with most studies. However, half-way through this experiment, a 10 msec. error in the switch was found.

they had seen an item. In case of the XI task, Ss were instructed to write down the letters below the appropriate matrix, on their response sheets. And, in the case of the P x I task, Ss were to report three letters in their correct positions. In all, these three tasks and in subsequent procedures, Ss were instructed to guess if they had to guess.

P Stimulus Cards: Ss, as in the case of the PX task, were to respond to presented stimulus cards by using the numbers 1 through to 3, on an appropriate response matrix.

I Stimulus Cards: Ss were simply to report the letters in the probe indicated column.

The five tasks -- PX, XI, P x I, P and I -- were administered within the probe delay conditions -- 0, 100, 250, 450 and 700 msec. -- yielding 5 x 5 treatment combinations. Fifty-six cards, or the entire set of stimulus material was exhausted for each treatment combination. Furthermore, each of the three 2 x 4 cell matrices or columns of letters was reported under each treatment combination, thus yielding 3 x 56 = 168 trials, under each treatment combination, for a total of 25 x 168 = 4200 trials, per S.

The 56 cards for each of the three sets of stimulus cards were randomly divided into seven groups of eight cards each. These card groups, were then administered in different random order for each treatment combination, as well as for each S. The order in which the probe directed Ss to report was determined randomly. However, the order of the probe, as well as the order of the cards, were fixed for different card groups (e.g., P x I card groups). After all seven groups had been exhausted for all the treatment combinations for all Ss, cards were then again randomly divided into seven groups, and were similarily administered to all Ss, under all treatment combinations. This procedure was repeated a third time, thus yielding 3 x 56 = 168 trials, under each treatment combination, where each of the three matrices or columns of letters was reported once, and only once.

The procedure was conducted in 21 different sessions, yielding eight trials for each treatment combination, in each session. Three Ss started with an ascending order of probe delays, beginning with the 0 msec. delay and ending with the 700 msec. delay, while the other Ss began with a descending order. Order was then altered between sessions. The order of the five tasks, within a delay condition, was determined randomly for each delay condition, within each session, between sessions and between Ss, but not, of course, across trials within a delay of probe condition. The stimulus card groupings were altered after session seven and session fourteen.

Each experimental session lasted anywhere from 40 - 60 minutes, depending on the particular S. In addition to the experimental sessions, each S received two practice sessions before data collection began. Moveover, each session began with 15 - 20 warm-up trials, depending on the time available, for that particular session. Generally, S, reported to the experimental session at the same time each day, for four days a week.

Under all conditions, Ss were asked to fixate on a small, centered, faint, back-lighted, fixation point, before the stimulus was presented. On a ready signal from S, E pressed the switch for stimulus presentation. E would change the stimulus card and if necessary, position of the probe, while S would be completing his response. Under all conditions, the response sheet was removed after every trial, to prevent undue interaction between consecutive reports.

Ss were required to come in for one or two make-up sessions, after the experiment was over. All trials, where S had not 'read' the probe correctly, i.e., responding to the center matrix when the left hand matrix should have been reported, were repeated. Most errors in reading the probe involved the two outside matrices. Thus, in order to prevent systematic experimental bias in the make-up session, a suitable number of dummy trials were included per S, so as to insure the probe would direct S to report each matrix 1/3 of the time.

Memory span data - i.e., where S had to report the entire stimulus array after a 60 msec. exposure was collected for each S for all tasks, throughout the last seven experimental sessions. Thus, eight trials for five tasks were performed by S during each of the last seven sessions, for a total of 40 trials per session.

SCORING AND DATA ANALYSIS: In the different procedures, where either position or letters had to be indicated, scoring simply consisted of; (a) number of positions correctly indicated on the response grid, and (b) number of letters correctly identified. In the P x I task, the following scoring procedures were used; (1) positions correctly reported, irrespective of content (p score), (2) letters correctly reported, irrespective of their noted position (i score), and (3) correct letters in their own correct positions (P x I score).

All measures, except for the P x I task, were corrected for guessing. Mean scores for left, right and center stimulus materials (mean of 56 trials), were derived for the six scores, defined above, for each S. These means, as well as the correction formula, are listed in Appendix B.

In accordance with traditional procedure (e.g., Sperling, 1960), mean performance was summed across the three segments of the stimulus material. These derived scores, for the different measures, are listed in Appendix C. In addition, these results are graphed in Figure 1.

A four factor analysis of variance, (repeated-measurement design), was performed on the p, PX, P, i, XI, and I, data. The four factors are, Ss x delay of probe x task x type of information (position and identity). Results of this analysis are listed in Table 1. In addition to this analysis, the same type of analysis was performed on the same data, but including memory span scores as a sixth level of the delay of probe variable. Results of this analysis can be found in Appendix D.

The data (p, PX, P, i, XI, and I), was subjected to a Tukey's HSD pair-wise task-mean procedure. Since none of the testable task interactions (See Table 1) proved to be significant, the three different types of task means, were pooled over, not only, delay of probe, but also over, types of information. Results of this analysis are listed in Table 2.

Finally, P x I performance -- the number of correctly identified and localized letters -- was analyzed, using a 2-factor repeated-measurement design (Ss x delay of probe). Results of this analysis are listed in Table 3.

TABLE 1

ANALYSIS OF VARIANCE OF PROBE DATA

Source of Variance		df	Mean Square	F
Subjects	(A)	5	28.93	
Delay of Probe	(B)	4	6.77	7.11*
Task	(C)	2	4.86	10.34*
Type of Information	(D)	1	56.75	10.14*
AB		20	0.95	
AC		10	0.47	
AD		5	5.60	
BC		8	0.25	1.06
BD		4	0.38	1.18
CD		2	0.40	1.94
ABC		40	0.23	
ABD		20	0.32	
ACD		10	0.21	
BCD		8	0.21	0.87
ABCD		40	0.24	

* $p < .05$

TABLE 2

DIFFERENCES BETWEEN TASK MEANS FOR PROBE DATA:
TUKEY's HSD TEST

Tasks	Means	1	2	3
1) *i*, *p*	5.58		0.08	0.61*
2) PX, XI	5.66			0.53*
3) P, I	6.19			

*$p < .05$ ($d = 0.34$; $q = 3.88$; $df = 3, 10$; $MS = 0.47$; $N = 60$)

TABLE 3

ANALYSIS OF VARIANCE ON P x I DATA
COLLECTED UNDER PROBE CONDITIONS

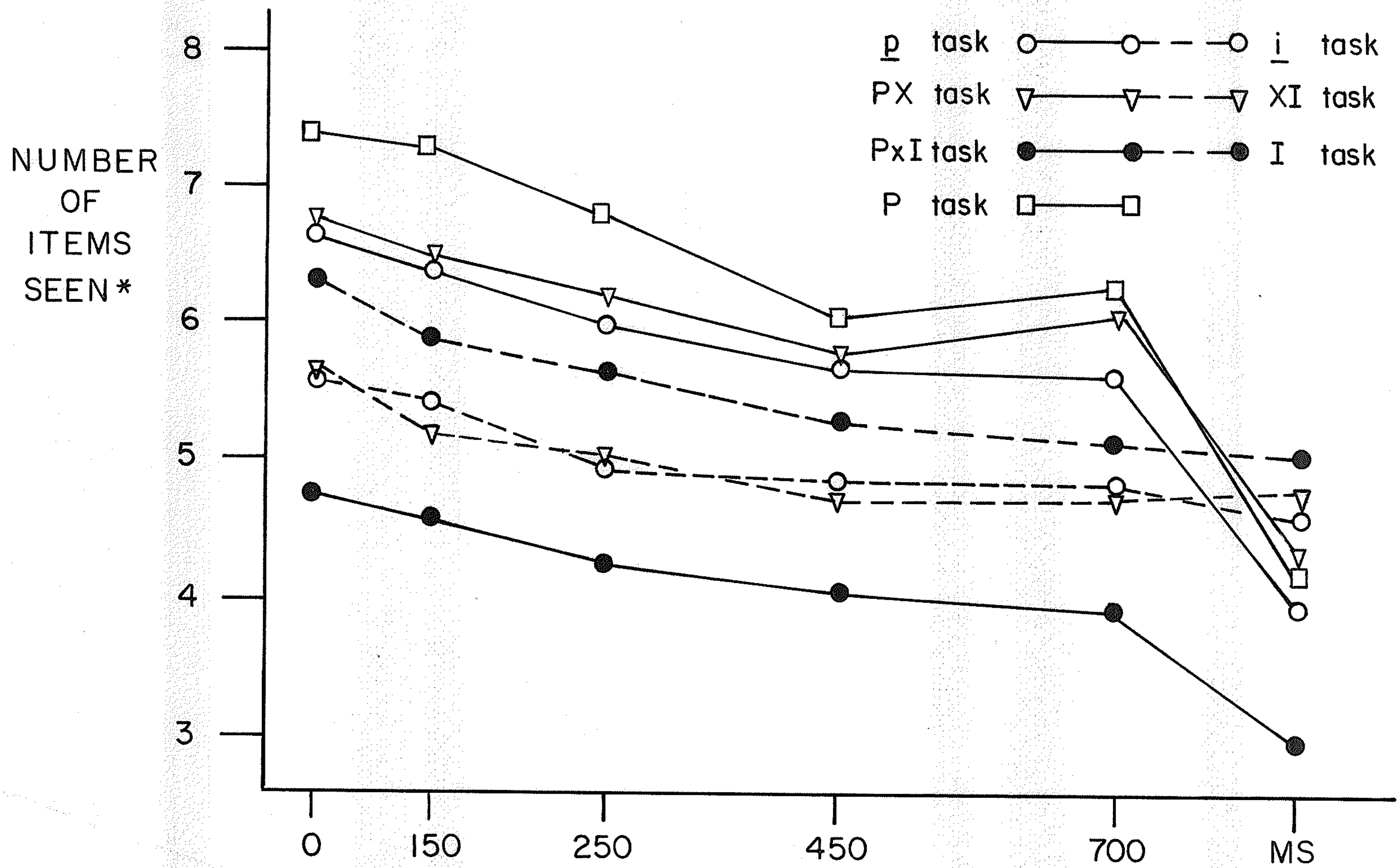
Source of Variance		df	M S	F
Subjects	(A)	5	5.43	
Delay of Probe**	(B)	4	0.72	4.48*
AB		20	0.16	

*$p < .05$

** Does not include memory span data

Fig. 1

PERFORMANCE ON THE VARIOUS TASKS AS A FUNCTION OF A DELAY OF PROBE



*Scores corrected for guessing except PxI performance

ILLUSTRATION 1

P x I STIMULUS CARD FOR PROBE EXPERIMENT

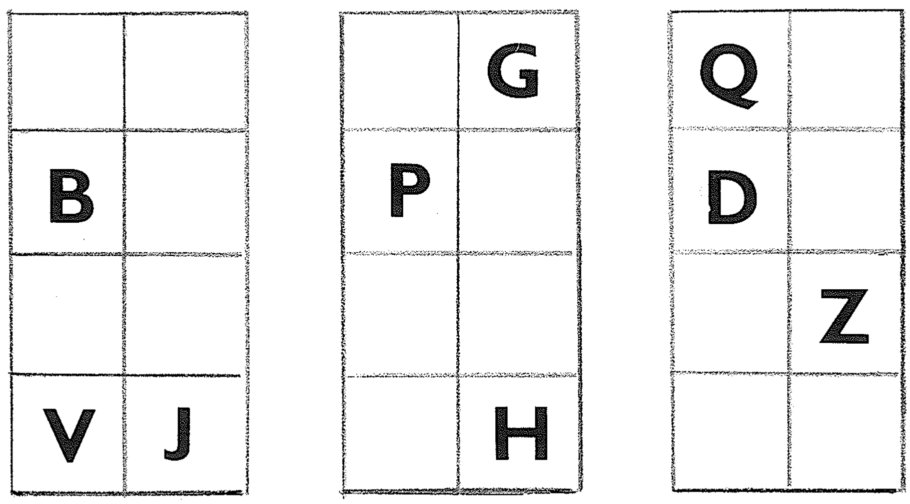


ILLUSTRATION 2

P STIMULUS CARD FOR PROBE EXPERIMENT

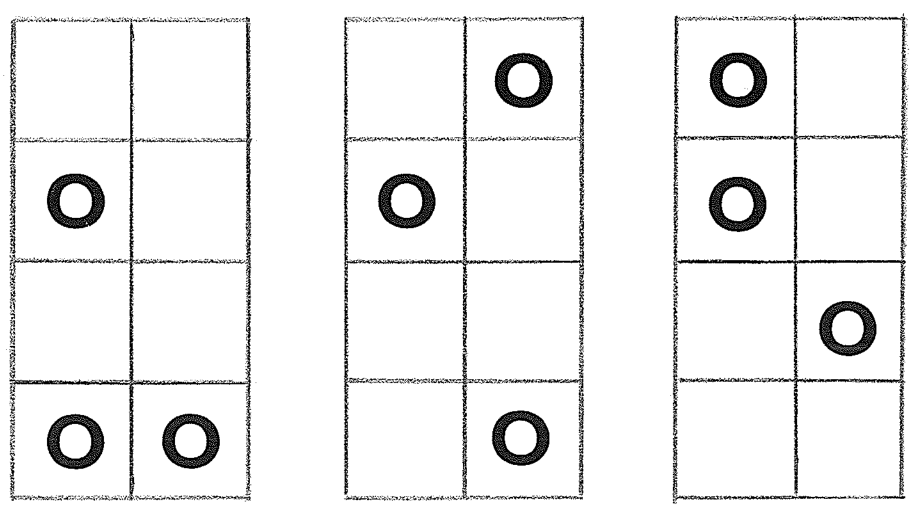


ILLUSTRATION 3

I STIMULUS CARD FOR PROBE EXPERIMENT

B	G	Q
V	P	D
J	H	Z

DISCUSSION: The present experiment was designed to obtain answers to at least three questions:

a). Whether or not, the probe technique, or perhaps better, the decay factor would be demonstrable with present stimulus materials, and the different tasks.

b). Whether or not, as speculated, positional information would be less subject to decay than identity information.

c). Whether or not, under conditions emphasizing visual persistence, the processing of both types of information -- position and identity -- would occur in an independent or dependent fashion.

In reference to the first question, the data clearly demonstrates that performance decreases as a function of delay of probe for all tasks and measures. This is reflected in significant delay of probe effect for both the p, PX, P, i, XI, and I, scores and P x I scores ($F = 7.11$; $df = 4, 20$; $p<.05$; $F = 4.48$; $df = 4, 20$; $p<.05$; respectively). Moreover, all Ss, except one, clearly followed the same pattern of results. Thus, despite changes in the stimulus material, the probe technique can be considered useful in giving an indication of the decay of information in visual storage.

The second question of interest, whether or not positional information continues to be retrievable from visual storage while not identity information, is clearly answered in Figure 1. First of all, Figure 1 illustrates that performance on position information is superior to that of identity information ($F = 10.14$; $df = 1,20$; $p<.05$). Moreover, the same Figure (1) indicates that performance on positional information at 700 msec. probe delay is well above memory span, while this is not so, in the case of identity information. This result supports the hypothesis that positional information is still stored to some extent in iconic storage, while identity information has suffered complete decay. This conclusion is also supported by a significant Delay of probe x Type of information interaction ($F = 14.90$; $df = 5, 25$; $p<.05$), if memory span data is included as a sixth level of probe delay variable (See Appendix D).

The third and major topic of interest is the question of perceptual independence or dependence. First of all, Figure 1, as well as the analysis of variance (Table 1), demonstrates that performance parity between tasks is violated ($F = 10.34$; $df = 2,10$; $p<.05$). A look at Figure 1 reveals that the loss of parity is across tasks that are instructionally the same, but perceptually different. (PX, XI--P, I). At the same time, there appears to be little or no loss of parity between tasks that are perceptually the same (or nearly so), but instructionally different. (p, i--PX, XI). These last statements are supported by Tukey's HSD test on pair-wise means of the different tasks listed in Table 2, which demonstrates that the mean of PX, XI tasks is significantly different ($p<.05$) from the mean of the P, I tasks, but not from the mean of the p, i tasks. These results then indicate that there is little or no interaction in the P x I task, due to the task requirement of responding on two variables, but there is a lack of perceptual independence. The locus of this perceptual dependence between position and identity information may be in visual storage, the encoding process, or perhaps, short-term memory span. Further interpretations best await results of further experiments.

One further result deserves comment. Figure 1 displays that the rate of information loss from visual storage is approximately the same for the various tasks. This is supported by the results of the analysis of variance in Table 1, where both the Delay of the probe x Tasks and Delay of probe x Type of information, fail to be significant ($F = 1.06$; $df = 8, 40$; $p>.05$; $F = 1.18$; $df = 4, 20$; $p>.05$; respectively). Thus, the rate of decay in iconic storage proves to be independent of whether positional, or identity, or both types of information, is stored. Again, discussion of the implications of this last result will be considered in the General Discussion.

FREQUENT ABBREVIATIONS

Stimulus Material	Task	Score
P x I cards A matrix containing randomly placed letters, fewer than the number of matrix cells.	**P x I task** Reporting both the identity and the matrix position of letters.	**P x I score** The nunber of correctly identified letters in their appropriate position.
		p score The number of correct positions indicated irrespective of identity in P x I task.
		i score The number of correct letters reported irrespective of position in the P x I task.
		P + I score Any correct letter position. (Includes P x I score).
	PX task Reporting only position when P x I cards are presented	**PX score** Number of positions correctly reported.
	XI task Reporting only letters when P x I cards are presented.	**XI score** Number of letters correctly reported.
P cards A matrix containing O's	**P task** Reporting position.	**P score** Number of positions correctly reported.
I cards Regular array of letters.	**I task** Reporting letters.	**I score** Number of letters correctly reported.

EXPERIMENT TWO

ENCODING OF POSITION AND IDENTITY

This experiment will attempt to determine the effect of backward masking on processing of position and identity information. One purpose central to this experiment, will be the determination of whether or not position and identity are processed in an independent or dependent fashion. Again, as in the previous experiment, dependence and independence will be evaluated by means of selectively manipulating, (a) the instructional task but not the perceptual task, and (b) perceptual task but not instructional task. Parity of performance, or the lack of it, will allow appropriate interpretation.

In addition to a comparison of absolute performance (parity), performance on the various tasks will also be examined as a function of delay of mask. This, then, will afford evidence with respect to rate of encoding of the different types of information, as well as the different tasks. Thus, for instance, if positional information is encoded at a different rate than identity information, different encoding mechanism are possibly indicated.

Liss (1968) has already indicated that identity processing may occur before position processing, since in a masking study, he discovered an increase in the number of reversals. However, this suggestion should be considered cautiously, since position, as such, was not treated as an independent variable. Ss actually knew all positions (e.g., four letters in a row). Although correct letters had to be correctly positioned, the nature of the processing may be quite different. For instance, temporal order of letters in short-term memory, or temporal order of rehearsal may serve as relevant position cues. This is not likely to be the case when position of randomly placed items must be processed.

APPARATUS AND STIMULUS MATERIALS: The same apparatus as in the previous experiment was utilized. As in Experiment 1, three different sets of stimulus cards were constructed. Again, all three sets used letters from Letraset Printpak No. 6, and white index cards. An example of each type of stimulus material may be seen in Illustrations 4, 5 and 6. The specification of each set of stimulus cards is as follows:

a). P x I cards, or cards containing randomly positioned letters. Stimulus cards consisted of a 6 x 4 matrix containing eight randomly positioned different letters from a subset of 24 letters -- O and U were not used. The following restrictions were placed in constructing the random array of letters; (1) each letter, within a particular card, was used once, (2) all 24 letters, within a set of stimulus cards occupied each of the 24 matrix cells, once, (3) no more than three letters were allowed to occupy any particular row or column, (4) common abbreviations and words, such as , MA, BA, AN, etc., were avoided. The total number of cards necessary to satisfy the aforementioned first requirements is 72, and such a number were constructed. The matrix cells were 0.98° x 0.74° in size.

b). P cards, were stimulus cards which were identical to those described above, except that all letters were replaced by O's, again yielding 72 cards.

c). I cards, were constructed by taking the letters from each stimulus card in the P x I cards, above, and simply arranging them in two rows of four letters. Separation between the columns and rows was 1.48° and 1.58°, respectively. Thus, the letters were spaced as to approximate the separation between letters in the P x I cards.

The mask was constructed by randomly placing and overlapping Letraset Printpak No. 6 letters on a white index card, so that approximately fifty percent of the surface was covered. An actual reproduction of the mask may be seen in Illustration 7.

PROCEDURE: As in Experiment 1, the procedure consisted of five different tasks (P x I, PX, P, XI, and I, tasks) as a function of the three different sets of stimulus cards. Stimulus cards were exposed for 30, 60, 90 and 120 msec., yielding 4 x 5 = 20 treatment combinations. All 72 cards were presented to S for any particular treatment combination resulting in 20 x 72 = 1440 experimental trials per S. The mask, which immediately followed off-set of the stimulus exposure was on for 250 msec. Luminance setting was approximately 20 ft. L. for both the stimulus and the mask.

Instructions for the different tasks were similar to those in the probe experiment. Thus, in the case of the P x I task, S had to correctly localize and identify eight letters on a matrix before him, guessing if he had to guess. Similarly, in the PX task (P x I cards were presented), and P task (P cards were presented), S had to localize items in a matrix, using numbers one through eight. Finally, in the case of the XI task (P x I cards were presented), and I task (I cards were presented), S had to identify eight letters, by simply writing them in a row. Again, in the PX, P, XI, and I tasks, S was instructed to guess if he had to guess.

Each set of 72 cards were randomly divided into nine groups of eight cards each. These were then administered in different random orders, for the various treatment combinations, as well as Ss. Eight trials per treatment combination were administered to each S per session, or each S received 20 x 8 = 160 trials per session. The different tasks were administered within stimulus exposure duration in a different random order for each such exposure duration as well as Ss. One half of the Ss began session one with an ascending series of stimulus exposure duration, beginning with 30 msec. and ending with 120 msec. exposure, while this was reversed for the remaining Ss, and altered over the sessions. Ss served in nine experimental sessions and one practice session, where they were familiarized with the different procedures. Furthermore, each session began with a few (10-15) warmup trials. Depending on S, each session lasted approximately 45 - 60 minutes.

Under all conditions, Ss were asked to fixate on a small, centered, faint, backlighted fixation point, before every stimulus presentation. On a ready signal from S, E would present stimulus. E would change the stimulus card, while S would be completing his response. Under all conditions, the response sheet was removed after every trial to prevent undue interaction between consecutive reports.

SCORING AND DATA ANALYSIS: As in Experiment 1, the five different tasks were scored to yield seven different performance measures, namely, p, PX, P, i, XI, I, and P x I, scores. Again, the various position measures simply reflect the number of matrix cells correctly reported and the various letter identification scores reflect the number of letters correctly identified. Except for the P x I scores, all measures were corrected for guessing. Performance scores for each S (mean of 72 trials) over the different exposure durations and tasks are listed in Appendix E. The performance on the different tasks are graphed as a function of delay of mask, in Figure 2.

A 4-factor analysis of variance was performed on the p, PX, P, i, XI, and I, scores. The results of this analysis are listed in Table 4. As in the case of Experiment 1, none of the testable task-interactions proved to be significant (See Table 4). Therefore, Tukey's HSD test was performed on pair-wise task means, where a task-mean consisted of an average of the data pooled over Ss, delay of mask, and type of information. Results of this analysis are listed in Table 5.

Finally, P x I performance -- the number of correctly identified, as well as localized letters -- was analyzed, using a 2-factor repeated-measurement design (Ss x Delay of mask). Results of this analysis are listed in Table 6.

TABLE 4

ANALYSIS OF VARIANCE OF MASKING DATA

Source of Variance		df	Mean Square	F
Subjects	(A)	5	16.78	
Delay of Mask	(B)	3	55.94	87.87*
Task	(C)	2	4.69	20.19*
Type of Information	(D)	1	0.19	0.21
AB		15	0.64	
AC		10	0.23	
AD		5	0.92	
BC		6	0.13	0.82
BD		3	0.86	3.51*
CD		2	0.13	0.72
ABC		30	0.16	
ABD		15	0.24	
ACD		10	0.18	
BCD		6	0.15	1.68
ABCD		30	0.09	

*$p < .05$

TABLE 5

DIFFERENCES BETWEEN TASK MEANS FOR MASKING DATA: TUKEY'S HSD TEST

Tasks	Means	1	2	3
1) p, i	2.04		0.36*	0.64*
2) PX, XI	2.40			0.28*
3) P, I	2.68			

*$p < .05$ (d = 0.27; q = 3.88; df = 3,10: MS = 0.23; N = 48)

TABLE 6

ANALYSIS OF VARIANCE OF P x I MASKING DATA

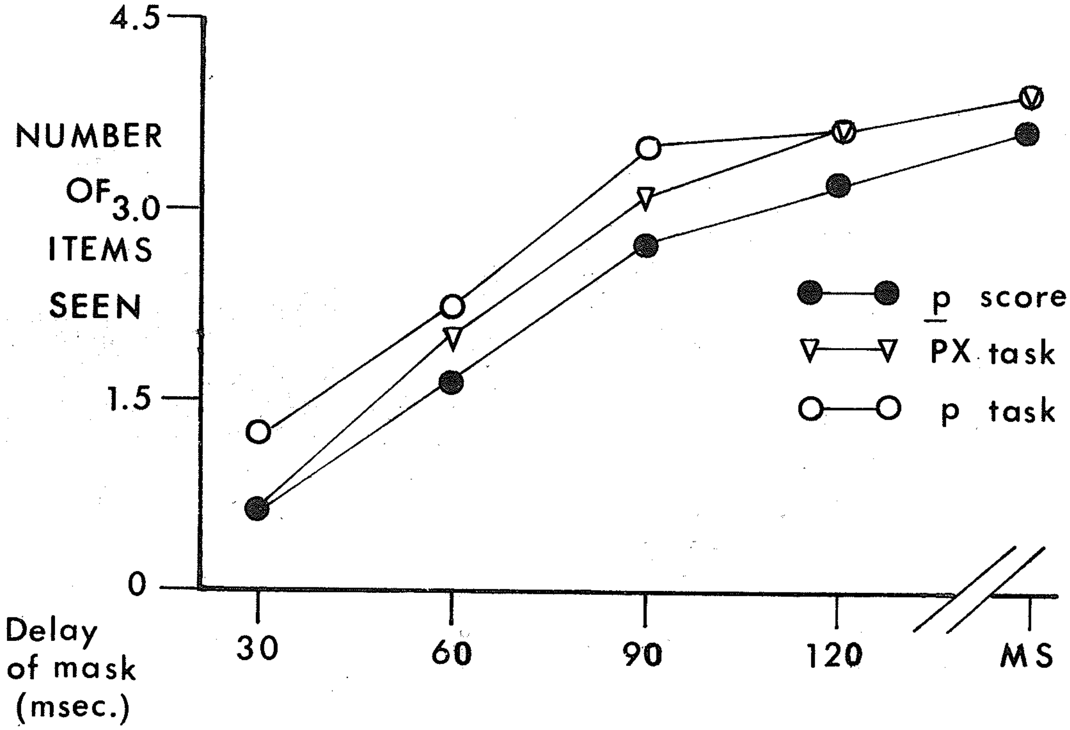
Source of Variance		df	M S	F
Subjects	(A)	5	0.56	
Delay of Mask	(B)	3	2.53	38.86*
AB		15	0.07	

$p < .05$

Fig. 2

MASKING PERFORMANCE ON:

(A) Position Tasks



(B) Identification Tasks

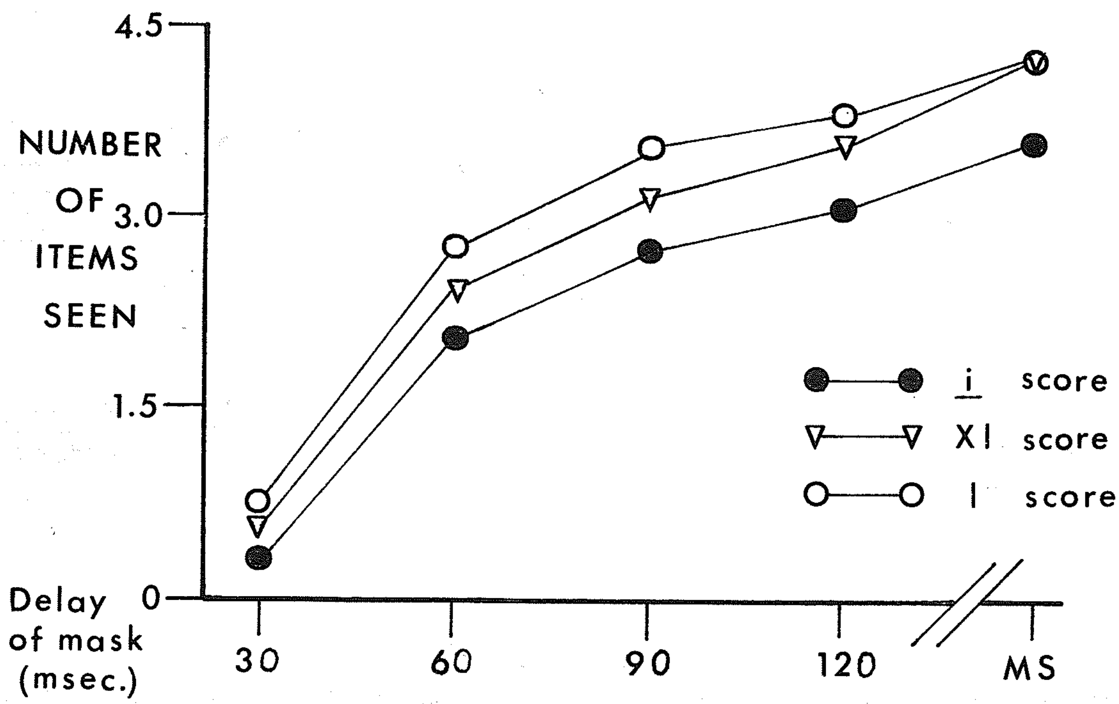


Fig. 3

MASKING PERFORMANCE, COLLAPSED OVER SUBJECTS AND TASKS

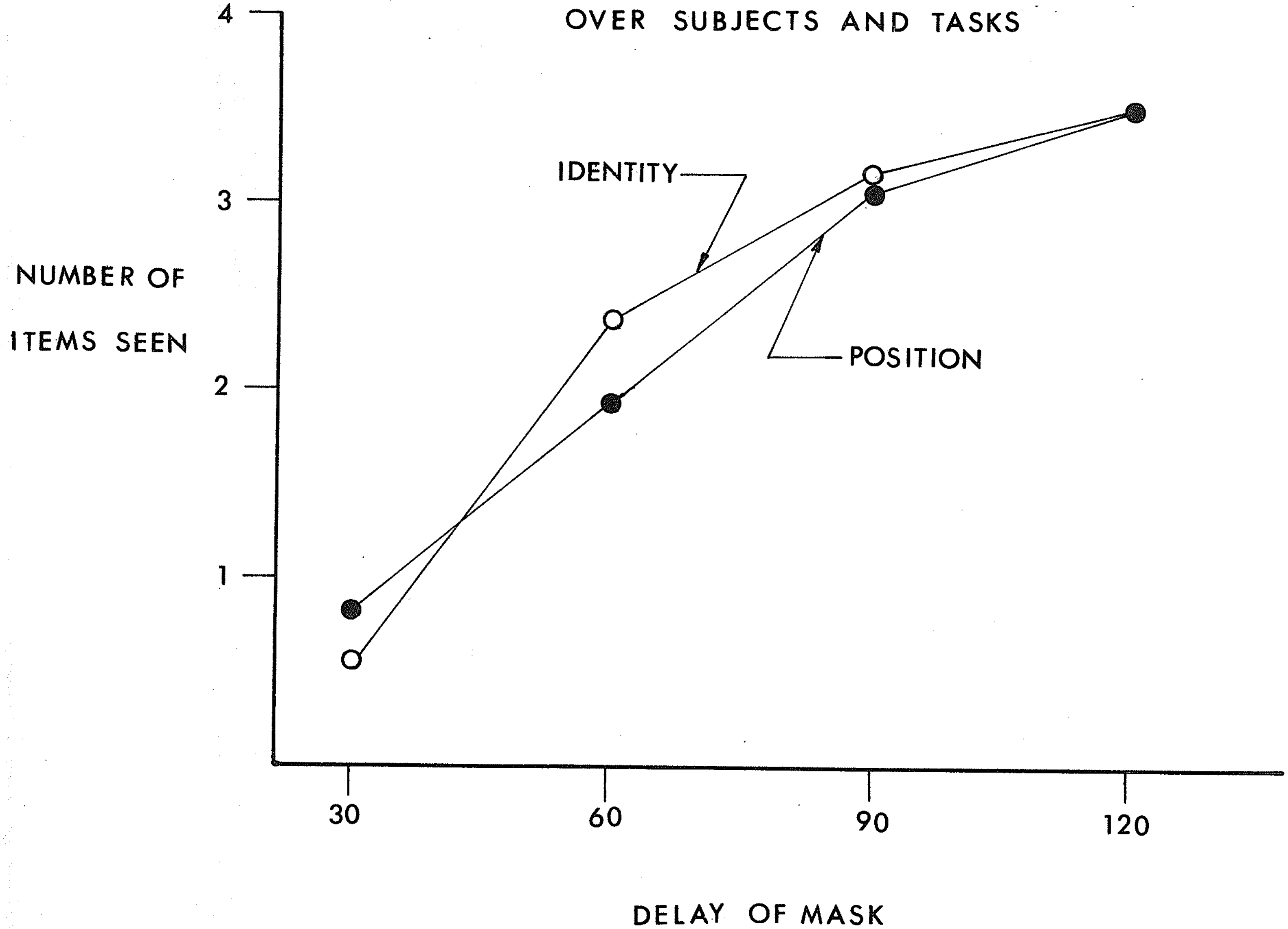


ILLUSTRATION 4

P x I STIMULUS CARD FOR MASKING EXPERIMENT

				K	
			S		T
R		H	V		
G				A	

ILLUSTRATION 5

P STIMULUS CARD FOR MASKING EXPERIMENT

				O	
			O		O
O		O	O		
O				O	

ILLUSTRATION 6

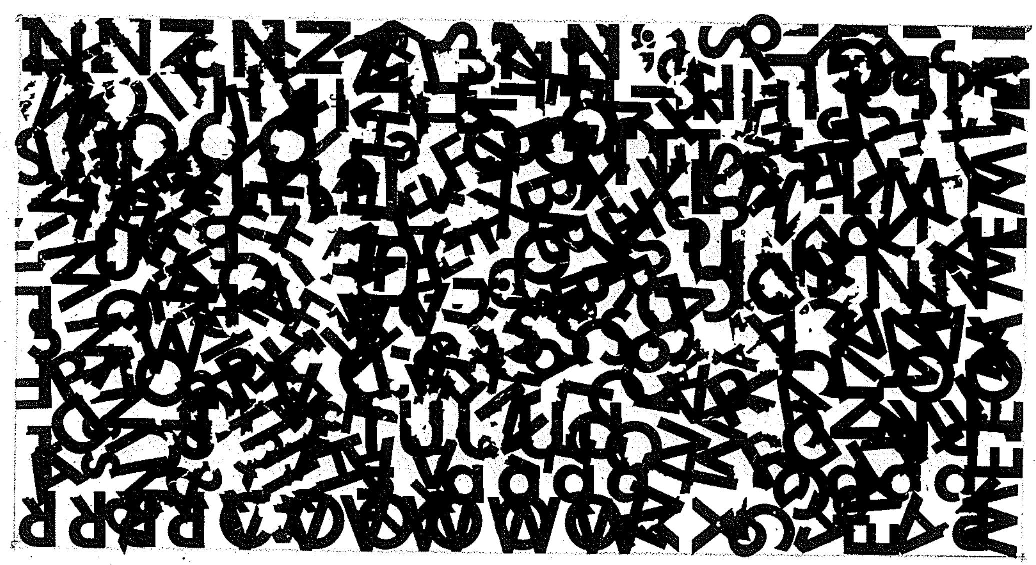
I STIMULUS CARD FOR MASKING EXPERIMENT

K S T R

H V G A

ILLUSTRATION 7

MASK USED IN MASKING EXPERIMENT



DISCUSSION: The present study was designed to yield information with respect to the question of independence and the question of rate of encoding. With respect to the question of independence, Figure 2, and the analysis of variance in Table 4 demonstrate that performance parity between tasks is violated ($F = 20.19$; $df = 2, 10$; $p<.05$). A look at Figure 2 reveals that the loss of parity is both across the tasks that are instructionally the same, but perceptually different (between PX--P, and between XI--I), and across tasks that are perceptually the same (or nearly so), but instructionally different (between p--PX, and between i--XI). These last statements are supported by Tukey's HSD test on pair-wise means of the different tasks at the .05 level, results listed in Table 5. These results, then, indicate that the loss of parity, in the case of P x I task, is caused both by interaction due to the task requirement of responding on two variables, and a perceptual interference. The locus of perceptual interaction, as revealed by the masking results, may originate in visual storage, short-term memory, or the encoding process itself.

With respect to rate of encoding, there are two problems to consider, First, there is the rate of encoding of the two different types of information, positional and identity information. Figure 2, as well as the analysis of variance in Table 4, demonstrate that the rate of encoding, for positional and identity information, are not the same -- hence the significant Delay of mask x Type of information interaction ($F = 3.51$; $df = 3, 15$; $p<.05$). This would suggest that positional and identity information are encoded separately, at least to some degree. The nature of the interaction is represented graphically in Figure 3, where the different position tasks have been collapsed into one mean for each delay of mask. The same was done for identity performance. Note, that between 30 and 60 msec., the rate of encoding for identity is faster than for position (1 item per 16.4 and 27.5 msec., respectively).

The second area of consideration, with respect to the rate of encoding, is between task comparison. It has already been established that there is a loss of parity between the three tasks for both position and identity variables. This loss of parity, however, is in reference to the absolute level of performance, but not in reference to the rate of encoding (slope of the lines in Figure 2). In fact, the Task x Delay of mask interaction is not significant ($F = 0.82$; $df = 6, 30$; $p>.05$), thus indicating that the rate of encoding, then, is independent of whether S must encode one stimulus dimension by itself, or in conjunction with another stimulus dimension. This last conclusion, in conjunction with a lack of perceptual independence (loss of parity), shifts the locus of interaction to visual storage.

Implications of these findings will be further discussed in the General Discussion.

EXPERIMENT THREE

SHORT-TERM MEMORY

The main purpose of the present experiment is twofold. First, the effect of exposure duration will be varied (30 - 90 msec.). That is, it has been demonstrated (Sperling, 1963) that encoding of identity takes place at such a rate that it fills up short-term memory before the icon decays. However, with the present set of stimulus materials, it may be that duration of visual storage or rate of encoding, at least in the case of the P x I task, is the limiting factor, rather than capacity of short-term memory. It is for this reason that exposure duration will be varied.

Secondly, the experiment is so designed as to determine whether or not storage of both position and identity occurs in an independent fashion. Again, performance parity, or lack of it, between the different tasks will serve as the criterion of independence.

APPARATUS AND STIMULUS MATERIAL: The same apparatus, as in the previous experiment, was used. The stimulus cards of Experiment 2, were used.

PROCEDURE: Five different tasks (P x I, PX, XI, P, and I, tasks) were administered as a function of the three different sets (P x I, P, and I, sets) of cards within three different timings -- 30, 60, and 90 msec. -- yielding 5 x 3 = 15 different treatment combinations. Each set of 72 cards was randomly divided into eight subgroups of nine cards each. These subgroups were then administered in different random orders for the various tasks, as well as Ss.

Within a session, Ss received nine trials per treatment combination for a total of 135 trials. The order of tasks within an exposure duration was determined randomly and in different random order for changes in exposure durations, as well as for different Ss. Ss were asked to fixate on a backlighted fixation point preceding every trial. On a ready signal from S, E presented stimulus. Luminance was set at approximately 20 ft. L. The stimulus card was changed as S was completing his response. The response sheet was removed after every trial to prevent undue interaction between consecutive reports.

RESULTS AND DISCUSSION: The responses were scored as in the other experiments, yielding seven performance measures (P x I, p, i, PX, XI, P, and I, scores). Except for the P x I score, all scores were corrected for guessing. Scores for each S (mean 72 trials, corrected for guessing) are listed in Appendix G.

A 4-factor analysis of variance was performed on the p, PX, P, i, XI, and I, data (Ss x Exposure x Task x Type of information). The results of this analysis are listed in

Table 7. Furthermore, a Tukey's HSD test was performed on task means on the same data listed in Table 8. Finally, a 2-factor (Ss x Exposure Duration) analysis of variance, was performed on the P x I data, and the results are listed in Table 9.

Exposure duration did not prove to be a significant variable. This is so for the f-factor analysis of variance ($F = 2.17$; $df = 2, 10$; $p > .05$), and the P x I performance ($F = 3.16$; $df = 2, 10$; $p > .05$). This then, supports the view that the capacity of memory span, rather than an encoding factor, is the constraint on amount of information processed under tachistoscopic memory span conditions.

The parity criterion for independence is clearly violated ($F = 29.09$; $df = 2, 10$; $p < .05$). This indicates some form of interaction, or lack of independence, between positional and identity information processing. Again, since none of the testable task interactions proved to be significant, a post hoc analysis (Tukey's HSD) was performed on task means, where the task means are means of data collapsed over Ss, duration of exposure, and type of information. The difference between task means, where the perceptual task is presumably the same but instructional tasks are not, proved to be significant at the .05 level (between p - i, and PX - XI). There is no difference in performance between the tasks that are instructionally the same but perceptually different (between PX - XI, and P - I). (See Table 8).

TABLE 7

ANALYSIS OF VARIANCE OF MEMORY SPAN DATA

Source of Variance		df	Mean Square	F
Subjects	(A)	5	12.46	
Exposure Duration	(B)	2	0.49	2.17
Task	(C)	2	3.65	29.09*
Type of Information	(D)	1	0.62	0.19
AB		10	0.23	
AC		10	0.13	
AD		5	3.22	
BC		4	0.21	2.68
BD		2	0.07	0.81
CD		2	0.19	1.24
ABC		20	0.08	
ABD		10	0.08	
ACD		10	0.15	
BCD		4	0.03	0.84
ABCD		20	0.04	

*$p \leq .05$

TABLE 8

TUKEY'S HSD TEST FOR PAIR-WISE TASK MEANS
ON MEMORY SPAN DATA

Tasks	Means	1	2	3
1) *p*, *i*	3.64		0.56*	0.65*
2) PX, XI	4.20			0.01
3) P, I	4.19			

*p < .05 (d = 0.23; q = 3.88; df = 3,10; MS = 0.13; N = 36)

TABLE 9

ANALYSIS OF VARIANCE ON P x I
MEMORY SPAN DATA

Source of Variance	df	M S	F
Subjects (A)	5	1.09	
Exposure Duration (B)	2	0.10	3.16
AB	10	0.03	

*p < .05

A NOTE ON AN ADDITIONAL PERFORMANCE MEASURE

In the task where S had to correctly localize and identify (P x I task), one other performance measure, not yet introduced, can be derived. The measure referred to, is letters correctly identified and localized in any correct position or conversely a correctly indicated position containing any correct letter (P + I score). This measure, then, includes P x I performance and a second component which may or may not be a chance component, depending on the nature of those p's and i's, not P x I, that S has available while making his report. If, for example, in the case of memory span, those p's and i's, not P x I, are completely independent from each other, then the P + I component not P x I, should be derivable simply by chance or probability considerations. On the other hand, if p and i are jointly stored but those p's and i's, not P x I, occur because of 'reversals' then, the P + I component not P x I, will be considerably larger than expected by chance.

Table 10 and Table 11 contain the actual P + I scores obtained for each S, as well as a derived P' + I score for memory span and masking data. As is obvious from these tables, the chance prediction of P + I is very accurate. Although analysis of variance were carried out on the two sets of data, it is likely that data of this nature does not meet the assumptions of such statistical treatment. This is supported by the extremely small P + I, F's obtained ($F = 0.04$; $df = 1, 5$; and $F = 0.03$; $df = 1, 5$; for masking and memory span).

From the above analysis, it can be concluded that those p's and i's, not P x I items are processed independently. The term processed here is used judiciously, since there is no way of knowing whether this lack of correlation between positions and letters not P x I, is a function of the encoding process, memory storage itself, such as independent decay, or some strategy by S.

TABLE 10

MEAN P + I PERFORMANCE, EMPIRICAL AND DERIVED VALUES FOR MASKING DATA

	EXPOSURE DURATION							
	30 msec.		60 msec.		90 msec.		120 msec.	
Subjects	actual	derived*	actual	derived	actual	derived	actual	derived
S1	0.90	0.85	1.33	1.26	1.93	1.87	2.54	2.47
S2	1.13	1.18	2.13	2.15	2.78	2.78	2.88	2.86
S3	1.18	1.29	1.54	1.60	2.29	2.40	2.69	2.71
S4	0.82	0.93	1.49	1.45	1.93	2.13	3.29	2.26
S5	1.57	1.55	2.12	2.42	2.75	2.58	3.28	2.98
S6	1.33	1.29	2.88	2.92	3.46	3.58	3.56	3.44
Mean	1.16	1.18	1.91	1.97	2.52	2.56	2.87	2.78

* derived $P + 1 = P \times I + \frac{(\underline{p} - P \times I)\ (\underline{i} - P \times I)}{N - P \times I}$

N = no. of responses = 8

$\underline{P}$, $\underline{i}$, P x I represent means of 72 trials uncorrected for guessing.

TABLE 11

MEAN P + 1 PERFORMANCE,
EMPIRICAL AND DERIVED VALUES
FOR MEMORY SPAN DATA

	Exposure Duration					
	30 msec.		60 msec.		90 msec.	
	actual	derived*	actual	derived	actual	derived
S1	2.51	2.62	2.61	3.07	2.92	2.85
S2	3.53	3.59	3.32	3.15	3.67	3.85
S3	2.36	2.55	2.81	2.92	2.74	2.76
S4	3.04	3.00	3.08	3.01	3.19	3.17
S5	3.04	3.06	3.43	3.38	3.38	3.31
S6	4.21	4.30	3.99	4.06	4.32	4.46
Mean	3.12	3.19	3.21	3.26	3.37	3.40

*derived $P + I = P \times I + \frac{(\underline{p} - PxI)\ (\underline{i} - PxI)}{N - PxI}$

N = number of responses = 8

$\underline{p}$, $\underline{i}$, P x I, represents means of 72 trials uncorrected for guessing.

FREQUENT ABBREVIATIONS

Stimulus Material	Task	Score
P x I cards A matrix containing randomly placed letters, fewer than the number of matrix cells.	**P x I task** Reporting both the identity and the matrix position of letters.	**P x I score** The nunber of correctly identified letters in their appropriate position.
		p score The number of correct positions indicated irrespective of identity in P x I task.
		i score The number of correct letters reported irrespective of position in the P x I task.
		P + I score Any correct letter position. (Includes P x I score).
	PX task Reporting only position when P x I cards are presented	PX score Number of positions correctly reported.
	XI task Reporting only letters when P x I cards are presented.	XI score Number of letters correctly reported.
P cards A matrix containing O's	P task Reporting position.	P score Number of positions correctly reported.
I cards Regular array of letters.	I task Reporting letters.	I score Number of letters correctly reported.

GENERAL DISCUSSION

The purpose of the present set of experimental investigations was to specify the characteristics of the processing of positional and identity information within the Sperling-type framework. To this end the performance on positioning tasks was compared to performance on identity tasks, under conditions presumably sensitive to (a) iconic storage and decay, (b) rate of encoding, and (c) capacity of short-term memory. Moreover, the nature of interaction, between the processing of position and identity information, was traced through the various stages of information processing. The criterion for independence was parity or lack of, between different identity (position) performance measures as generated by (a) the task, where S has to process both position and identity information, and (b) the task where S was presented with, and had to report, only one kind of information. In case there was a loss of parity or lack of independence, for either type of information, a third task was administered, namely, presenting both types of information, but responding selectively to one type of information. Position or identity performance in the third task helps to indicate, at least to some degree, whether or not any interaction is located at the perceptual or response end of the stages of information processing, present in any particular experiment. The results of the independence aspect of the present set of investigations are summarized in Table 12.

In comparing position performance to identity performance in the probe technique, two results are immediately apparent. These results are: (a) the rate of decay of information in iconic storage is approximately the same for locations and letters, and (b) position performance is superior to identity performance, while this is not so for memory span data, with the same stimulus materials. At first glance, the first result, namely, identical decay rates for position and identity information, appears to indicate that both position and identity fade more or less as a unit, at least in the case of P x I task. However, it should be pointed out that position and identity information could possibly decay along independent (separate) lines.*

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*This use of the word independence should not be confused with independence as defined by the performance parity criterion. The former use refers to whether information is processed jointly or separately, the latter refers to whether processing of two or more types of information interfers with each other. Garner & Morton (1969) differentiate between these two 'independent' meanings of the word independent, as state and process independence respectively.

TABLE 12

SUMMARY OF

PARITY COMPARISONS

	d_1	d_2
Probe Technique	N.S*	S**
Masking	S	S
Memory Span	S	N.S

d_1 = difference between different instructional tasks, e.g., p - PX or i -XI

d_2 = difference between different perceptual tasks, e.g., PX - P or XI - I

*N.S - not significant at $p<.05$ level

**S - significant at $p<.05$ level

Thus, it may well be that the overall structure of iconic storage is subject to distortion quite separate from decay of the fine structural detail (identity) that makes up the overall structure. Had it happened to be the case, that the rates of decay were different for position and identity information then iconic decay along separate dimensions would have been implicated. The fact that rates of decay are the same is not sufficient to negate the separate decay possibility.

A similar note of caution must be voiced about the interpretation placed on the finding that position performance is superior to identity performance under conditions of partial report. This fact was used to support the hypothesis that positional information would be more resistant to decay than identity information, since the latter information is dependent on fine structural detail. That is, fine structural detail can decay to the point where identification is no longer possible, but leaving enough information to allow localization. Again, the possibility exists that the pattern may be subject to decay and distortion independent, at least to some extent, of decay of fine structural detail. Thus, under some conditions it may be possible to obtain results that would, (a) demonstrate different rates of decay for position and identity information, and (b) inferior, or superior, (or both), position performance in comparison to identity performance. Certainly, the present results suggest a uniformly fading image where all structural aspects fade concomitantly, but also suggest that identity, at any point of decay, as being less specifiable than locations, since identification necessitates a more definitive degree of structural detail in iconic storage. However, further experimentation is necessary in validating or invalidating such an interpretation.

The above has concerned itself with comparing position performance to identity performance under conditions of partial report. To be considered next, are the parity comparisons between tasks within a type of information. Such comparisons clearly demonstrated loss of parity or the existence of perceptual interaction. It should be noted, that the nature of interaction was such, that it detracted from both position and identity performance, in the P x I tasks and the PX and XI tasks. That is, whenever both types of information were present in stimulus materials, it detracted from S's positioning and identity performance, irrespective of whether S had to process one or both types of information, as compared to positioning and identity performance, when only one type of information was present in stimulus materials. Expressed in abbreviated terms, there was a loss of parity between P - PX tasks, between I - XI tasks, between P - p measures and between I - i measures, but not between *i* - XI measures and not between *p* - PX measures. Or, there was a loss of parity between tasks that were perceptually different but no loss of parity between tasks that were instructionally different, thus arguing for perceptual interaction.

As was mentioned in the brief discussion following the probe experiment, it was not feasible at that point, to attribute the lack of perceptual independence to processes in iconic storage, the encoding process, or short-term memory process. It can be expected, that although short-term memory is part and parcel of the probe experiment, its role will be minimal. In the probe experiment, *Ss* response consisted of three items which generally falls within the capacity of memory span. Moreover, if loss of parity in the probe experiment was due to short-term memory processes, then both the data from the probe experiment and memory span experiment should demonstrate a similar loss of parity. This is not the case. In the case of the probe data, there is no loss of parity between the *p* - Px and between *i* - XI performance measures, while there is loss of parity between those same measures in memory span data. In short, the perceptual interaction obtained in the probe data cannot be attributed to tachistoscopic short-term memory process. For reasons that will be developed later, the perceptual interaction obtained in the probe technique cannot be attributed to the encoding process. This is so, despite the fact that there is a similar loss of parity in the masking data.

Assuming that the locus of interaction obtained in the probe data is visual storage, its nature deserves some comment. If iconic storage is a relatively passive process or an isomorphic representation of the stimulus such as an afterimage, then it is difficult to understand why performance parity between the different tasks is not the case. If, on the other hand, iconic storage is an active, dynamic or constructive process, one possible explanation suggests itself. It may well be that the more complex the stimulus, the more difficult it is to maintain information in visual storage, or the more difficult it is to maintain a visual image. It appears reasonable that in the present situation randomly positioned letters defines a more complex stimulus than either a similar patters of O's, or a regular array of letters. Complexity, then, is defined along structural lines.

The above mentioned possibility can be further specified, by postulating an inverse relationship between structural complexity, and either stability or clarity, of iconic storage. With respect to the stability possibility, one would expect different rates of iconic decay associated with structural complexity. However, the results revealed no interaction between type of task and delay of probe. Or, in other words, rate of information loss from iconic storage is independent of whether one or two types of information is present in visual storage. Thus, it is unlikely that structural complexity is associated with stability of iconic storage. It must be noted, however, that this possibility is not completely ruled out, since at the 0 msec. delay of probe, the obtained data already reflects a large degree of decay, in view of the fact that it may take up to 200 msec. for S to process the probe (Eriksen & Collins, 1969). It is possible that during this initial period of iconic decay, a Task x Delay of probe interaction exists. However, the fact remains that the present data does not warrant the supposition that stability or rate of iconic decay, is inversely related to structural complexity.

This leaves the alternate possibility, that of clarity being inversely related to structural complexity. For whatever reasons, the more complex the stimulus, such as a random collection of letters as compared to a random collection of O's, the less clear the (decaying) stimulus representation is in iconic storage, given brief stimulus presentation of equal energy. Such a conceptualization should first be subject to further empirical efforts of validation or invalidation (i.e., threshold study, probe studies, or perhaps one of the direct measures of visual storage suggested by Haber & Standing, 1969), before proceeding with any speculation as to why a structurally more complex stimulus is associated with a lower degree of clarity.

Another finding, in reference to the probe experiment must be mentioned, namely, the fact that there was no evidence for response interaction. That is, there was no loss of parity between p score and PX performance or between i score and XI performance. Or, in other words, S was as capable at positioning (identification), irrespective of whether or not he had to respond on one or two types of information. The word response may, but not necessarily so, be taken to mean response to the contents of iconic storage. This, of course, alludes to the familiar problem of the distinction between perceptual and response processes. When considering such sub-processes as iconic storage, encoding and so on, this problem is further complicated. However, the fact remains, that somewhere along the different stages of information processing, S, when faced with the XI or PX task, has to respond on only one dimension. Note that this does not necessarily imply the encoding process since it may well be possible that both types of information are encoded, despite the fact that S has to report only one type of information. The fact, of course, still remains that there was no loss of parity between processing both dimension of stimulus information and selectively processing one dimension of stimulus information when responding to the same (P x I) stimulus materials. Thus, it appears that the response of identification and response of positioning are completely compatible when combined into a P x I response. Note that S has to respond on only three items -- well within short-term memory capacity for p and i scores. The response compatability present in the probe data may not occur when the constraints of storage capacity of short-term memory is an influence.

Given one assumption, then the fact that p score and PX performance, or the i score and XI performance was the same, indicates one other interesting possibility. The assumption referred to is, where the selection of the relevant stimulus dimension takes place in the PX or XI task. If it is assumed that the encoding process is capable of selecting only one dimension from iconic storage, then the fact that there is no loss of parity between the p and PX measures, or between the i or XI measures, implies that position and identity information is encoded simultaneously in the P x I task. That is, if position and identity are encoded serially in some fashion, i.e., one position, then one letter, or vice versa, then the number of retrievable positions and letters should be far less than in the task where S must encode only one type of information, since decay of icon leaves only a finite amount of time for encoding to occur. This is not to imply that position or identity information, by itself, is not encoded serially, nor is it implied that position and identity information is encoded jointly. The simultaneous encoding of both types of information will be further considered in discussing the results of the masking procedures.

The above discussion has emphasized the visual persistence, or tail-end, of visual storage. That is, the probe technique is presumably sensitive to the process of decay in iconic storage. However, the information in iconic storage must be transferred to some short-term system. The masking procedures were performed to examine the information transfer process, from visual or iconic storage to short-term memory. Unlike the probe technique, the masking procedure will, to some extent, reflect or be sensitive to, processes taking place at the initiation of iconic storage.

The backward masking procedures revealed, among others, three important results. They are: (1) the rate of encoding of positional information is significantly different from the rate of encoding of identity information as evidenced by a significant Type of information x Delay of mask interaction ($F = 3.51$; $df = 3, 15$; $p>.05$;) (2) the rate of encoding is approximately the same for the different tasks, for a type of information (Task x Delay of mask; $F = 0.82$; $df = 6,30$; $p>.05$), and, (3) there is a loss of parity between the different tasks, indicating some form of interaction.

The fact that the rate of encoding is different for the two types of stimulus information (also in P x I task), suggests the possibility that different mechanisms are responsible for the encoding of positional and identity information. The possibility that different mechanisms are operating or responsible for noting position and identity information is not too surprising in as much as position and identity are different types of information. The fact that type of information is encoded at different rates not only suggests that separate mechanisms are encoding information but that they also encode information separately. This latter fact, of course, poses the problem of how S arrives at a correct P x I response. That is, if position and identity are encoded separately, by separate mechanisms, in the P x I task, then where in the several stages of information processing, are these separate items of information matched or integrated into proper P x I responses? At the present stage, any further speculation should first involve a validation of whether or not position and identity information are actually encoded separately. Once this fact has been confirmed, then, different models for the attainment of a correct P x I response may be postulated.

As has been pointed out in the results and discussion sections of Experiment 2, the processing of position and identity information, under masking conditions, demonstrates a mutual perceptual interaction as revealed by a loss of parity between performance on the PX and P tasks, as well as between the XI and I tasks. Since S's reports, under masking conditions involve iconic storage, short-term memory as well as the encoding process, the locus of the interaction can be in any of these sub-processes. If, however, the obtained perceptual interaction is due to short-term memory, a similar loss of parity could be expected in memory span data. Since the memory span data does not demonstrate a loss of parity between the PX and P tasks, nor between the XI and I tasks, the obtained perceptual interaction in the masking study cannot be attributed to short-term memory processes.

The perceptual interaction obtained in the masking data is not of such a nature where it affects the rate of encoding of the different tasks. That is, the rate of encoding of position information is the same in the P, or P x I tasks, and is the same for the I, or XI tasks. (Delay of mask x Task; $F = 0.82$; $df = 6,30$; $p > .05$). The fact that the rate of encoding is independent of whether S must report one type of information, shifts the locus of interaction or loss of parity to the time it takes to encode the initial item(s), or rather, to when after stimulus presentation the initial item(s) can be encoded. Once this has taken place, the information transfer from iconic storage proceeds at the same rate for a type of information irrespective of the task (this includes i or p performance in the P x I task, as well). The latter statements imply that encoding is serial or sequential in nature, but the statements are equally applicable, if encoding, within type of information, is a parallel process.

One available interpretation of the above results, follows from the microgenetic approach -- the growth, or development of a percept (e.g., Flavell & Dragnus, 1957; Kaswan, 1958; Kaswan & Young, 1963). There is little doubt that an image has to be constructed or developed (e.g., Neisser, 1967). Presumably, a randomly arranged pattern of different letters takes longer to differentiate into a clear image, or visually stored pattern, than either a pattern of O's, or a regular array of letters. Should the above interpretation be correct, then S would have more available processing time for the P, or I, tasks than the tasks where P x I stimulus materials are presented.

Notwithstanding the validity of the microgenetic interpretation, it does not account for the loss of parity between the PX and p or XI and i performance measures, or between those tasks where P x I stimulus materials were presented to S. Again, the loss of parity is such where the rate of encoding is independent of the nature of the task, within a type of information. One possibility, is that in case of the XI and PX tasks, encoding can start as soon as items establish themselves in visual storage, whereas, in the case of the P x I task, initiation of encoding may be delayed until both the position and identity aspect of items are established. Note, such a possibility would not reflect itself in the probe data, since it is sensitive to decay, rather than initiation of iconic storage. Another possibility for the loss of parity, between the PX and *p* or XI and *i* measures, is the added task requirement of responding on eight items (as compared to three items in the probe experiment), which may produce some interfering effect on the *i* and *p* measures in the P x I task. In any case, it is clear that any interpretation which would alter the rate of encoding, for *p* or *i* measures, is unsuitable. Other than that, any interpretation as to why the loss of parity, between the PX and *p* or between the XI and *i* measures, amounts to little more than speculation.

One other finding in the masking procedures, not yet introduced, should be given some consideration. There was no overall difference in the positioning and identity performance levels ($F = 0.21$; $df = 1, 5$; $p > .05$). Given the possibility that the superior position performance, as compared to identity performance in the probe data, reflects a differential sensitivity to iconic decay, or degradation as discussed earlier, then the masking results can be viewed as support for the notion that masking by visual noise interrupts the readout process from iconic storage. For instance, if backward masking degrades iconic storage, it would be reasonable to expect that masking would serve as a favourable bias toward position performance. That is, degradation would presumably affect fine structural detail (identity) to a greater extent, than gross structural detail (position). On the other hand, it has been pointed out that decay in iconic storage might occur along independent lines, as far as position and identity is concerned, position decay being in part, a function of distortion of pattern. Since the patterns used in the probe and masking studies are not strictly comparable, any interpretations as the above may not be warranted. Nevertheless, the data can be so interpreted as to support the interruption or erasure theory of the effect of backward masking. Such an interpretation can perhaps be further validated or invalidated by generating masking curves under conditions which clearly produce summation or degration such as a bright flash of light for a mask (Eriksen, 1966), and a condition with visual noise as a mask, using stimulus materials with two types of information (P x I cards). Any differential masking effects on the type of information can then be determined by comparison across masking conditions.

The aforementioned, has been concerned with the results of the probe and masking data. Inasmuch as information is stored in short-term memory, whether data is generated under conditions of partial report or masking, memory span data was collected. The major purpose of measuring the capacity of short-term memory was, (a) to aid in the tracing or specification of the locus of independence between the processing of position and identity information, and (b) to determine to what extent capacity of short-term memory is dependent on duration of visual storage or rate of encoding with the present type of stimulus materials. With respect to this last objective exposure duration was varied from 30 - 90 msec. And, as has been mentioned earlier, exposure duration did not have any significant effect on memory span for any of the performance measures. Therefore, it is reasonable to conclude that tachistoscopic memory span reflects a process not sensitive to the constraints of iconic storage or its decay and not sensitive to the constraints of the encoding process.

With respect to determining whether or not position and identity information was processed independently under conditions emphasizing tachistoscopic short-term memory, parity comparisons were performed. The analysis demonstrated a loss of parity between the different tasks. The loss of parity occurred between the p and PX and also, between the i and XI performance measures, while there was no loss of parity between the PX and P or between the XI and I tasks. Thus, there was no loss of parity between tasks requiring response on one type of information despite differences in stimulus materials and there was a loss of parity between tasks requiring one or two dimensional report even though stimulus materials were the same. Note that this is a complete reversal of the parity loss found in the probe data. There, the loss of parity was a function of different stimulus materials and not a function of whether S had to report one or two types of information.

Before commenting on the possible nature of the interaction obtained in the memory span data, it may be of value to stress the differences between the probe technique and memory span procedure. First, the loss of parity, evident in the memory span experiment, is not present in the data derived from the probe experiment, presumably because in the latter, the demand on short-term memory is small -- only three items per trial. On the other hand the interaction found in the probe experiment is absent in the memory span data, presumably because the process underlying tachistoscopic memory span is not sensitive to the constraints of (decaying) iconic storage as evidenced by a lack of exposure duration effect on capacity of storage for all performance measures.

The above discusses the differences between data derived from the probe and memory span experiments, possibly accounting for the fact that interaction obtained in one procedure will not occur in another procedure. However, it does not account for the loss of parity found in the memory span data. One explanation stems from the fact that the PX or XI tasks, or the tasks where S was instructed to selectively process one type of information, when two types of information are present in the stimulus materials, are functionally equivalent to the P or I tasks, where S responds to stimulus materials containing only one type of information. Presumably, the irrelevant stimulus dimension in the case of PX or the XI tasks no longer plays an important role; that is, there is little or no storage of the irrelevant stimulus dimension in short-term memory when S responds selectively to one type of information, thus making the PX and P, or the XI and I tasks, equivalent. Note that this is not the case for iconic storage, or the data derived from procedure sensitive to iconic storage. On the other hand, the loss of parity obtained in the memory span data, as revealed by the i - XI, and p - PX comparisons, stems from the fact that both position and identity has to be stored in short-term memory, in the case of the P x I task. The nature of this interaction is not clear. In order to specify the nature of the interaction it would be necessary to investigate such factors as; Is visual and verbal short-term memory, joint or separate in nature? What is the nature of rehearsal for positional information, identity information, and so on? At present, it may be concluded that when both positional and identity information must be stored in short-term memory, not quite as many items of either type of information are stored, as when only one type of information is stored in short-term memory. It is also clear that the nature of the interference or interaction is quite unlike that derived from iconic storage or for that matter, the encoding process.

One general comment must be made in reference to the findings of interaction. Even though there is a loss of parity involved in the different experimental results, it must be emphasized that this loss of parity is small. Obviously, interference or interaction is not an all-or-none affair, but a matter of degree. In case of the encoding and memory span data, loss of parity amounts to loss of ½ an item, or less. This, then, indicates that the simultaneous processing of the two types of information, position and identity, is to a very large extent, compatible or independent. This is so, despite the fact that S, in the P x I task, must not only process positions and identities, but also, is required to process a specific relationship between a particular position and identity. In fact, it may well be this additional requirement that is responsible for the interaction, or loss of parity, in the memory span data.

SUMMARY AND CONCLUSIONS

Tachistoscopic studies concerned with the information processing approach to perception have generally used alpha-numeric stimulus materials. The criterion of information processed is usually some measure of Ss capacity or ability to identify. Other dimension of stimulus information have received little attention. Three experiments were performed which compared the processing of 2-dimensional location or position information to the processing of identity information. The experiments involved were; (a) the probe technique, where iconic decay was studied, (b) masking procedures, where rates of information transfer or encoding, was investigated, and (c) tachistoscopic short-term memory, where memory span and the effect of exposure duration, was examined. In addition, each experiment was so designed as to allow determination of whether or not position and identity information is processed independently. Independence or lack of it was determined, by the parity criterion between three types of tasks, involving (a) processing of both types of information, when both were present in stimulus materials (letters randomly positioned in a grid), (b) selectively processing one type of information when both types of information were present in stimulus materials, and (c) processing one type of information when only one type of information was present in stimulus materials (e.g., grid containing randomly placed O's, or regular array of letters).

The probe experiment demonstrated comparable rates of decay for positional and identity information. However, positional information gained more benefit from procedure of partial report than did identity information. The possibility that fine structural detail (identity) is more sensitive to iconic decay than is overall structure (position) was discussed in reference to superior position performance. S's reports or scores revealed a loss of parity or interaction between tasks which involved iconic storage of two types of information, and storage of one type of information. There was no loss of parity between position or identity performance when both had to be processed simultaneously or when they were processed selectively, in response to the same stimulus materials. The interaction was attributed to an inverse relationship between structural complexity of stimulus and clarity of the (decaying) icon.

The main findings of the backward masking experiment are; (a) different rates of encoding of position and identity information, (b) approximately equal performance levels of position and identity information,

(c) a loss of parity between three different types of tasks, and (d) rates of encoding for position and identity information independent of the nature of the task. The results were interpreted, or possible interpretations were suggested: involving an appeal to the microgenetic point of view; an interruption theory of masking; and, the possibility of different encoding mechanisms for position and identity information.

The results of the experiment on short-term memory, demonstrated that: (a) duration of exposure had no effect on tachistoscopic memory span for any of the various performance measures; and (b) that there was a loss of parity between those tasks where S had to report only one type of information, and the task where S had to report both position and identity information. The fact that the nature of interaction was different from the probe technique and the fact that duration of exposure was not an important variable was interpreted to mean that the two procedures (memory span, and probe technique) reflected different underlying processes or mechanisms, lending further validity to the probe methodology.

Finally, the fact that loss of parity or interaction effects were small, was considered. The possibility was raised that the interaction effects, at least in the case of the masking and memory span procedures, may be due to the fact that in the task requiring processing of both types of information involved the additional procedure of processing a specific relationship between position and identity.

The methodological approach of the present set of empirical investigations deserves some comment regarding its usefulness. First, the empirical results have validated Garner & Morten's (1969) statement that the emphasis of the 'independence methodology' should consist of a search for interaction. Certainly, the interpretations and future validation or invalidation, of the interpretations of the nature of interaction as indicated by the present results, leads to a further description of the several stages of information processing. The second point concerns the fact that investigations within the information processing approach should be extended to multiple types of information. Comparative evaluation of the processing of different types of information under identical or nearly identical experimental conditions can lead to further insights into the nature of the various processing mechanisms.

FREQUENT ABBREVIATIONS

Stimulus Material	Task	Score
P x I cards A matrix containing randomly placed letters, fewer than the number of matrix cells.	**P x I task** Reporting both the identity and the matrix position of letters.	**P x I score** The nunber of correctly identified letters in their appropriate position.
		p score The number of correct positions indicated irrespective of identity in P x I task.
		i score The number of correct letters reported irrespective of position in the P x I task.
		P + I score Any correct letter position. (Includes P x I score).
	PX task Reporting only position when P x I cards are presented	PX score Number of positions correctly reported.
	XI task Reporting only letters when P x I cards are presented.	XI score Number of letters correctly reported.
P cards A matrix containing O's	P task Reporting position.	P score Number of positions correctly reported.
I cards Regular array of letters.	I task Reporting letters.	I score Number of letters correctly reported.

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APPENDICES

APPENDIX A

LIST OF P x I STIMULUS MATERIALS USED IN PROBE EXPERIMENT

Note each stimulus card has been coded as below.

Cell 1

1	2
3	4
5	6
7	8

Cell 2

1	2
3	4
5	6
7	8

Cell 3

1	2
3	4
5	6
7	8

CARD	SPACES Cell 1								Cell 2								Cell 3							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
1			B				V	J		G	P					H	Q		D			Z		
2			G		P		T		F		Z				Y		D	C		Q				
3	Q		D			Z							L	K	X			S		L				Z
4	S					R		P				V		H		W				T	G			N
5	M				Y			K		W		P		X				J	Y	B				
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
6		J	Y	B							Q	G	D				Z	N			K			
7	X			N			D		M				Y			K		T				G		F
8				F	B	T			D	C		Q					V		L					G
9		W		P		X				D			H	W				B	V				N	
10						V	R	T		B	V				N			G	P					H
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
11		S		L				Z		Q		S	F						X	Y			Z	
12	K				R		F			V			N		M				S			N	K	
13	N						W	Y			H	D				M			F	R	[illegible]	Y		
14		M	W		J								W	J		R		P					J	C
15		T				G		F		J	Y	B					S					R		P
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8

CARD	SPACES Cell 1								Cell 2								Cell 3							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
16				V		H		W			B				V	J			G		P		T	
17			Q	G	D						S			N	K		K	F						Q
18			X	Y			Z					Z		P	L							V	R	T
19				K	T		Q		Q		D			Z					Q	G	D			
20		R	M			Q				S		L				Z			C		V	B		
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
21	V		L					G				K	T		Q						L	K	X	
22	C	Y					H		X			N			D						S		B	D
23	R			H		C				T				G		F	T		K	X				
24	K	F						Q		M	W		J				B			W	Q			
25	G	Z				F					C		V	B			Y				M	S		
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
26	H	L	R									T	G			N				Z		P	L	
27					W	J		R				F	B	T						M			S	V
28			N		Z			S	C	Y					H			Q		S	F			
29		B	V				N		V		L					G		M	W		J			
30	B			W	Q						N		Z			S	H	L	R					
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
31				T	G			N		K		J			P		P		J		C			
32		Q		S	F				H	L	R							V			N		M	
33	J					L	G					M			S	V	F		Z				Y	
34			H	D				M	L			C				B			T			D		X
35	Y				M	S							S		B	D		X				M	C	
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8

CARD	Cell 1								SPACES Cell 2								Cell 3							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
36	L			C				B	J					L	G					K	T		Q	
37		K		J			P			H			X			L			N		Z			S
38		D			H	W			P		J		C				G	Z				F		
39					L	K	X			P					J	C		W		P		X		
40	P		J		C									V	R	T		R	M			Q		
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
41		X				M	C		B				W	Q			M				Y			K
42			T			D		X	R			H		C				D			H	W		
43		G	P					H	N						W	Y	K				R		F	
44				M			S	V			X	Y			Z		R			H		C		
45				Z		P	L		K				R		F		X			N			D	
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
46			C		V	B					G		P		T		J					L	G	
47	D	C		Q						R	M			Q			L			C				B
48		P					J	C	Z	N			K				C	Y					H	
49			F	R		Y			S					R		P	N						W	Y
50		V			N		M		Y				M	S						V		H		W
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
51					S		B	D		X				M	C						W	J		R
52			S			N	K				F	R		Y				K		J			P	
53	F		Z				Y		K	F						Q					X		H	L
54		H			X			L	G	Z				F						F	B	T		
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
55	T		K	X					T					D		X			B				V	J
56	Z	N			K				T		K	X							H	D				M
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8

APPENDIX B

PROBE DATA AS A FUNCTION OF SUBJECTS, TASKS, DELAY OF PROBE, AND PORTION OF STIMULUS MATRIX

TABLE 1

PERFORMANCE ON THE PROBE TECHNIQUE AS A FUNCTION OF LEFT, RIGHT AND MIDDLE MATRICES FOR THE VARIOUS POSITION TASKS

Subject	Delay of Probe															Task
	0 msec.			100 msec.			250 msec.			450 msec.			700 msec.			
S1	2.07	2.76	2.26	1.81	2.85	1.81	1.30	2.68	1.81	1.27	3.00	1.78	1.30	2.38	1.03	
S2	2.38	2.74	2.31	2.47	2.59	2.31	2.09	2.85	2.09	1.61	2.93	1.63	2.47	2.76	1.83	
S3	1.49	2.78	1.69	1.69	2.76	1.72	1.52	2.38	1.52	1.20	2.53	1.20	1.94	2.51	0.71	
S4	1.61	2.78	2.21	0.93	2.72	1.94	0.75	2.85	1.46	0.71	2.64	1.27	0.75	2.62	0.96	R
S5	1.20	2.44	1.27	1.69	2.68	1.33	1.61	2.64	1.24	1.55	2.51	1.17	1.86	2.64	1.07	
S6	2.66	2.80	2.40	2.35	2.32	2.31	2.04	2.81	2.17	2.04	2.81	2.04	2.24	2.66	1.99	
S1	2.04	2.80	2.12	1.49	2.83	1.89	1.27	2.81	1.97	1.24	2.70	1.52	1.37	2.72	1.61	
S2	2.42	2.96	2.57	2.26	2.87	2.53	1.86	2.78	2.17	1.86	2.80	2.02	2.80	2.80	1.64	
S3	1.94	2.83	1.58	1.37	2.78	2.04	1.49	2.59	1.75	1.33	2.53	1.61	1.67	2.85	1.97	
S4	1.17	2.89	2.26	1.24	2.66	1.37	1.14	2.81	1.49	0.96	2.62	1.10	0.39	2.70	1.10	PX
S5	1.00	2.57	1.49	1.30	2.64	1.40	1.81	2.68	1.33	1.49	2.74	1.37	2.17	2.68	1.17	
S6	2.49	2.27	2.42	2.62	2.81	2.35	2.35	2.80	2.12	2.21	2.80	1.81	2.26	2.91	2.02	
S1	1.97	2.83	2.26	2.17	2.80	2.09	1.86	2.80	2.07	1.20	2.66	1.33	1.03	2.80	1.14	
S2	2.61	2.91	2.76	2.81	2.85	2.74	2.40	2.89	2.59	2.31	2.96	2.31	2.64	2.81	1.81	
S3	2.14	2.87	2.14	2.07	2.85	2.09	1.75	2.80	1.91	1.07	2.89	1.49	2-17	2.98	2.02	
S4	1.78	2.95	2.24	1.58	2.87	2.12	0.78	2.85	1.49	0.67	2.62	1.07	0.59	2.51	1.49	P
S5	1.78	2.89	1.86	1.78	2.93	1.69	2.02	2.93	1.64	2.09	2.85	1.17	2.33	2.81	1.33	
S6	2.93	2.95	2.68	2.83	2.93	2.53	2.64	2.89	2.42	2.33	2.85	1.94	1.99	2.81	2.02	

TABLE 2

PERFORMANCE ON THE PROBE TECHNIQUE AS A FUNCTION OF LEFT, MIDDLE AND RIGHT MATRICES FOR THE VARIOUS LETTER INDENTIFICATION TASKS

Subject	Delay of Probe															Task
	0 msec.			100 msec.			200 msec.			450 msec.			700 msec.			
S1	0.82	2.28	1.26	0.86	2.39	0.91	0.57	2.29	0.91	0.75	2.41	0.97	0.54	1.76	0.03	
S2	1.62	2.69	2.04	1.47	2.76	2.31	1.04	2.62	1.57	1.19	2.64	1.54	1.82	2.67	1.82	
S3	1.13	2.56	1.04	0.93	2.54	1.21	0.84	2.58	1.13	0.59	2.43	0.88	0.84	2.43	0.86	
S4	1.30	2.79	2.04	0.84	2.69	1.76	0.82	2.78	1.08	0.59	2.62	1.34	0.68	2.60	1.28	i
S5	0.77	2.33	1.02	0.95	2.41	1.06	1.24	2.45	0.88	0.88	2.33	1.11	0.97	2.58	1.00	
S6	2.43	2.86	2.45	2.24	2.82	2.16	2.02	2.86	1.98	1.86	2.73	2.18	2.18	2.62	2.16	
S1	0.82	2.56	1.49	0.73	2.10	1.15	0.52	2.45	1.08	0.59	2.35	0.66	0.29	1.74	0.10	
S2	1.36	2.76	2.24	1.21	2.67	2.04	1.13	2.76	1.72	1.19	2.65	1.30	2;16	2.78	1.43	
S3	1.11	2.60	1.08	1.02	2.52	1.34	1.06	2.56	1.02	0.93	2.31	0.84	0.70	2.56	0.80	
S4	1.60	2.80	1.82	0.88	2.60	1.80	0.80	2.82	1.19	0.37	2.50	1.32	0.57	2.69	1.51	XI
S5	0.88	2.41	1.24	0.64	2.43	0.86	1.11	2.33	0.73	1.15	2.22	1.00	1.02	2.52	0.59	
S6	2.43	2.82	2.33	2.24	2.95	1.98	2.02	2.82	1.92	1.92	2.89	2.06	2.18	2.86	2.33	
S1	0.84	2.20	1.17	0.54	2.33	0.93	0.43	2.33	0.66	0.36	2.20	0.64	0.36	2.04	0.43	
S2	2.12	2.95	2.65	1.74	2.95	2.60	1.72	2.93	2.35	1.45	2.98	1.92	2.22	2.87	0.84	
S3	1.12	2.86	1.34	1.24	1.87	0.93	1.02	2.87	0.97	1.04	2.71	0.97	0.91	2.71	0.77	
S4	1.88	2.95	2.16	1.21	2.93	2.28	0.75	2.89	1.84	0.50	2.86	1.66	0.77	2.78	2.00	I
S5	0.84	2.87	1.15	0.73	2.73	1.08	1.30	2.82	1.21	1.04	2.67	1.19	1.11	2.62	1.02	
S6	2.80	3.00	2.86	2.64	2.95	2.35	2.41	2.96	2.35	2.41	2.87	2.24	2.37	3.00	2.20	

TABLE 3

PERFORMANCE ON THE PROBE-TECHNIQUE AS A FUNCTION OF LEFT, MIDDLE, AND RIGHT, MATRICES FOR THE PXI TASK

Subject	Delay of Probe (msec.)					Matrix
	0	100	250	450	700	
S1	0.68	0.70	0.41	0.68	0.39	
S2	1.21	1.30	0.82	0.75	1.45	
S3	0.79	0.68	0.66	0.59	0.61	Left
S4	0.96	0.50	0.59	0.50	0.50	
S5	0.64	0.86	0.98	0.71	0.77	
S6	2.20	1.70	1.63	1.34	1.71	
S1	2.16	2.18	2.04	2.28	1.57	
S2	2.50	2.59	2.54	2.54	2.50	
S3	2.45	2.39	2.21	2.21	2.21	Middle
S4	2.45	2.39	2.63	2.25	2.34	
S5	1.89	2.23	2.23	2.04	2.29	
S6	2.70	2.54	2.57	2.66	2.36	
S1	1.05	0.80	0.77	0.80	0.30	
S2	1.70	1.93	1.21	0.93	1.14	
S3	0.75	0.95	0.98	0.82	0.55	Right
S4	1.61	1.23	0.73	0.96	0.68	
S5	0.68	0.70	0.73	0.57	0.50	
S6	1.86	1.89	1.75	1.77	1.70	

APPENDIX C

PROBE DATA AS A FUNCTION OF SUBJECTS, TASKS, AND DELAY OF PROBE

TABLE 1

MEAN PERFORMANCE ON PROBE TECHNIQUE
FOR THE DIFFERENT POSITION TASKS

Subject	Delay of Probe (msec.) 0	100	250	450	700	Memory-Span	Task
S1	7.09	6.46	5.78	6.05	4.71	3.38	
S2	7.42	7.36	7.04	6.17	7.06	4.97	
S3	5.96	6.17	5.41	4.94	5.16	2.97	
S4	6.60	5.59	5.06	4.61	4.33	2.92	p
S5	4.92	5.70	5.48	5.23	5.57	4.19	
S6	7.85	6.98	7.02	6.90	6.89	5.33	
Mean	6.64	6.38	5.97	5.65	5.62	3.96	
S1	6.96	6.21	6.05	5.45	5.69	4.16	
S2	7.96	7.67	6.80	6.67	7.23	4.82	
S3	6.35	6.18	5.83	5.47	6.48	4.31	
S4	6.32	5.26	5.44	4.68	4.19	3.25	PX
S5	5.06	5.33	5.82	5.59	6.01	4.19	
S6	7.78	7.79	7.27	6.82	7.19	5.33	
Mean	6.74	6.41	6.20	5.78	6.13	4.35	
S1	7.06	7.06	6.72	5.19	4.97	3.51	
S2	8.28	8.40	7.89	7.58	7.26	4.09	
S3	7.16	7.01	6.46	5.45	7.17	3.36	
S4	6.96	6.57	5.12	4.35	4.59	3.63	P
S5	6.53	6.40	6.58	6.12	6.48	4.97	
S6	8.55	8.29	7.95	7.12	6.82	5.36	
Mean	7.42	7.29	6.79	5.97	6.21	4.15	

TABLE 2

MEAN PERFORMANCE ON PROBE TECHNIQUE
IDENTITY INFORMATION

Subject	Delay of Probe (msec.)						Task
	0	100	250	450	700	Memory-Span	
S1	4.39	4.16	3.77	4.13	2.33	4.13	
S2	6.35	6.55	5.32	5.37	6.31	4.97	
S3	4.73	4.69	4.55	3.90	4.13	3.88	
S4	6.13	5.29	4.68	4.55	4.56	4.39	i
S5	4.12	4.43	5.57	4.32	4.55	4.24	
S6	7.73	7.21	6.86	6.77	6.95	5.58	
Mean	5.58	5.39	4.94	4.84	4.81	4.56	
S1	4.87	3.98	4.05	3.60	2.12	3.79	
S2	6.37	5.92	5.61	5.15	6.37	5.36	
S3	4.79	4.88	4.64	4.08	4.07	4.22	
S4	5.68	5.28	4.81	4.39	4.77	4.39	XI
S5	4.53	3.93	4.17	4.36	4.13	4.41	
S6	7.58	7.16	6.76	6.87	7.37	6.36	
Mean	5.64	5.19	5.01	4.74	4.80	4.76	
S1	4.21	3.81	3.42	3.19	2.83	3.32	
S2	7.72	7.28	7.00	6.35	5.94	5.58	
S3	5.32	5.04	4.87	4.72	4.39	4.47	
S4	6.99	6.42	5.48	5.01	5.56	5.20	I
S5	4.86	4.54	5.33	4.90	4.74	4.91	
S6	8.66	8.16	7.73	7.52	7.57	6.57	
Mean	6.29	5.87	5.64	5.28	5.17	5.01	

TABLE 3

MEAN PERFORMANCE ON THE
PROBE TECHNIQUE ON P x I TASK

SUBJECTS	DELAY OF PROBE					
	0 msec.	100 msec.	250 msec.	450 msec.	700 msec.	Memory Span
S1	389	368	320	377	227	248
S2	541	582	457	421	509	321
S3	400	402	386	363	338	230
S4	504	413	395	371	352	289
S5	338	379	395	332	357	293
S6	677	613	611	573	573	405
Mean	475	459	427	406	393	298

A P P E N D I X   D

ANALYSIS OF VARIANCE ON PROBE DATA INCLUDING MEMORY-SPAN PERFORMANCE AS A SIXTH LEVEL OF THE PROBE DELAY VARIABLE

ANALYSIS OF VARIANCE ON PROBE DATA INCLUDING MEMORY-SPAN PERFORMANCE AS A SIXTH LEVEL OF THE PROBE DELAY VARIABLE

Source of Variance		df	Mean Square	F
Subjects	(A)	5	31.86	
Delay of Probe	(B)	5	15.96	17.39*
Task	(C)	2	4.84	9.31
Type of Information	(D)	1	37.53	6.77*
AB		25	0.92	
AC		10	0.52	
AD		5	5.64	
BC		10	0.28	1.33
BD		5	4.82	14.90*
CD		2	0.29	1.37
ABC		50	0.21	
ABD		25	0.32	
ACD		10	0.21	
BCD		10	0.22	1.01
ABCD		50	0.22	

$*p < .05$

APPENDIX E

LIST OF P x I STIMULUS MATERIALS
USED IN THE MASKING AND
MEMORY SPAN EXPERIMENTS

Note each stimulus card has been coded as below.

CODE

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24

CARD	SPACES																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1					L					Z		P	R		Y	J			G				A	
2		M					R		N		T	Y					H	L			A			
3	M				I	E				R	G						L		Z		P			
4			Y	Z							C					P		V		I			D	K
5	S			J					R				Z	M							Y	L		A
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
6		Y	G			L		M			Z		B				I			E				
7		A	Q			D				V						S			W		X		C	
8				S						P		X	V		L	W					Z			C
9	B				D		Q				H			P				F		V		W		
10				T	Q							K	D		F	M				W			B	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
11		F	D				H		A		E			G								Z		L
12		P				V		B	Q								D	W	H			F		
13			F	M		W		I	H						D								L	B
14		G					A		M	F					H			Z	E			Y		
15	H				S					D		F	G				Q				K		M	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

CARD SPACES

CARD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
16	X				V	A					L			F		R					D			M
17	I			R				H		G		D					S		L		F			
18				L	N		I				W		E	A						D	Q			
19				P		I		S								Z			C			V	K	D
20		R	B					Y			I		K	H				M				C		

CARD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
21	R			K			X		B			W					Y			H			Z	
22	F				B		G			T	N			K					M			I		
23			S	C				F	G			R					B			M				V
24		K				M		E								G	W	I	N			J		
25		L	X			N				Q			T	J							V	P		

CARD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
26	E			G	W						M			L	X			J		N				
27			R				S		E			L	J	X		I						B		
28	N				K			J	Z							E			Y	P				R
29						C	V	T	W						I				A				N	P
30					F	G					Q		I	D					B			E	T	

CARD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
31			W		X		T	G					M			Q				Y	B			
32		D		Q						I	B						F	E		G				T
33	G					Y			T	M			S		W		X		Q					
34					P	T		D				B		N		H			J		G			
35	T		I				W			S	J						P			B				N

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

CARD	SPACES 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
36		E		X					C			N			J			T				A	I	
37	D	N							V		A	G								C			P	I
38		J		H			C							E		X		A			N	T		
39			N		E			Z		X				W		D		S			T			
40	Z	W	D									T	X		N		E					S		

CARD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
41	C				J	P				A		Q		I			Z					D		
42			E	V					J	C				T					S			N		Q
43		T					J				S	M	C		E	V							Q	
44	V		Z							L	X			C				N					W	S
45		I			Z			C					A		Q		J	D		T				

CARD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
46				F		Z	L		K								R		D	S	C			
47						S			L		D	C				F			X	Z				W
48		C			R	Q	K	V					L		Z						M			
49	L		M					A			K					B			P	R			S	
50	Q		K	A						W							T	H			I		J	

CARD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
51		X			T		E	Q				I			K	A						H		
52				T			P	K		Y				Z				Q	F		E			
53				N		K			S	J			F								L		R	E
54			H		G		M	X								T	V	Y		A				
55					H		N			B		A		Y	G				T	L				

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

SPACES

CARD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
56	K	Z										E	Y		S	C					R		V	
57				I					P		F		W		T			B				Q		J
58				B		R		L			P				M			X	K	Q				
59	A				M				F			S	H	Q	V								G	
60		Q	V				F			H							M				S	X		G
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
61					Y	H	B	R	X								K	P			W			
62			A			J		P				H		B					V			K	F	
63	P	B							I	E						L	N	K						F
64			L	W							V	Z	P		A					J	H			
65	J			E		P	Z		Y					V			C					G		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
66	W			Y		F										N	G			K			E	X
67		S	C					W								Y		R		F			X	H
68		V			C		Y			N	R				P			G			J			
69					A	X	D							S	C							R	H	Y
70	Y	H								K				R	B			C	I			M		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
71			J					N			Y	V	Q		R	K								Z
72			P						D			J	N				A		R	X			Y	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

A P P E N D I X   F

MASKING DATA AS A FUNCTION OF SUBJECTS, TASKS, AND DELAY OF MASK

TABLE 1

MEAN PERFORMANCE ON MASKING PROCEDURES: POSITION TASKS

Subjects	Delay of Mask					Task
	30 msec.	60 msec.	90 msec.	120 msec.	Memory span	
S1	0.00	0.61	1.93	2.98	3.22	
S2	0.52	2.21	3.20	3.10	3.41	
S3	0.73	0.90	2.52	3.10	3.38	
S4	0.16	0.58	2.16	2.47	3.27	P
S5	1.49	2.47	2.72	3.77	3.98	
S6	1.07	2.98	3.90	3.88	4.62	
Mean	0.66	1.63	2.74	3.22	3.65	
S1	0.00	0.82	2.69	3.63	3.43	
S2	1.07	2.26	3.41	4.58	4.29	
S3	0.55	2.14	2.74	3.24	3.54	
S4	0.00	0.34	1.71	2.64	3.03	PX
S5	0.70	2.49	3.54	3.70	3.81	
S6	1.46	3.75	4.22	4.25	5.06	
Mean	0.63	1.97	3.05	3.67	3.86	
S1	0.16	0.28	1.95	3.20	3.61	
S2	1.95	3.05	4.20	3.83	4.39	
S3	1.13	2.39	3.38	3.68	4.31	
S4	0.16	0.79	2.49	2.67	3.63	P
S5	1.74	2.81	3.94	3.77	4.41	
S6	2.15	3.69	4.69	4.69	5.13	
Mean	1.21	2.17	3.44	3.64	4.25	

TABLE 2

MEAN PERFORMANCE ON MASKING PROCEDURES: IDENTIFICATION TASKS

Subjects	Delay of Mask					Task
	30 msec.	60 msec.	90 msec.	120 msec.	Memory span	
S1	0.00	0.61	0.82	2.34	1.82	
S2	0.00	2.35	3.34	3.17	3.90	
S3	0.82	1.69	2.32	2.89	3.36	
S4	0.00	0.73	2.32	2.16	3.63	i
S5	0.58	2.76	3.05	3.24	3.54	
S6	0.40	4.01	4.37	4.54	4.68	
Mean	0.30	2.02	2.70	3.06	3.49	
S1	0.00	0.46	1.30	1.71	2.47	
S2	0.55	3.15	3.75	4.20	4.72	
S3	0.96	2.64	3.03	3.70	3.68	
S4	0.00	1.63	2.98	3.45	4.50	XI
S5	1.18	3.05	3.68	3.94	4.24	
S6	1.41	3.47	4.27	4.74	5.44	
Mean	0.68	2.40	3.17	3.62	4.17	
S1	0.00	0.67	1.05	2.11	2.19	
S2	1.33	2.89	4.12	4.12	4.94	
S3	0.84	2.98	3.20	3.86	3.86	
S4	0.00	2.49	3.74	3.63	4.62	I
S5	1.05	2.98	3.80	3.50	4.33	
S6	1.23	4.61	4.97	5.47	6.12	
Mean	0.74	2.77	3.65	3.78	4.34	

TABLE 3

P x I PERFORMANCE UNDER MASKING CONDITIONS

Subjects	Delay of Mask				
	0 msec.	60 msec.	90 msec.	120 msec.	Memory span
S1	0.07	0.75	1.35	2.06	2.53
S2	1.07	2.46	3.18	2.90	3.44
S3	1.33	2.03	2.50	2.76	3.18
S4	0.10	0.50	1.38	2.35	2.94
S5	1.35	1.96	2.58	2.78	3.40
S6	1.85	2.50	3.07	3.42	3.44
Mean	0.96	1.70	2.34	2.71	3.16

A P P E N D I X   G

MEMORY SPAN DATA AS A FUNCTION OF SUBJECTS, TASKS, AND EXPOSURE DURATION

TABLE 1

PERFORMANCE ON MEMORY-SPAN TASKS

	Exposure Duration							
	30 msec.	60 msec.	90 msec.		30 msec.	60 msec.	90 msec.	
Tasks	Position Scores			Subjects	Identity Scores			Tasks
	3.38	3.22	3.29	S1	1.79	1.82	2.59	
	3.86	3.41	4.18	S2	4.68	3.90	5.06	
	2.79	3.38	2.86	S3	2.89	3.36	3.45	
P	3.10	3.27	3.47	S4	3.45	3.63	3.42	i
	3.36	3.98	3.83	S5	3.34	3.54	3.68	
	4.72	4.62	4.86	S6	5.06	4.68	5.27	
	3.53	3.65	3.75	Mean	3.53	3.49	3.91	
	3.59	3.43	4.50	S1	2.06	2.47	2.96	
	4.66	4.29	4.88	S2	5.51	4.72	5.71	
	3.68	3.54	3.59	S3	3.88	3.68	3.77	
PX	3.22	3.03	3.50	S4	4.33	4.50	4.39	XI
	4.27	3.81	3.70	S5	4.14	4.24	4.94	
	5.46	5.06	4.76	S6	5.91	5.44	5.59	
	4.14	3.86	4.15	Mean	4.30	4.17	4.56	
	4.29	3.61	4.22	S1	2.11	2.19	2.08	
	4.03	4.39	4.52	S2	4.96	4.94	5.34	
	3.45	4.31	3.59	S3	3.66	3.86	3.72	
P	3.43	3.63	3.81	S4	4.20	4.62	4.41	I
	3.13	4.41	3.74	S5	3.86	4.33	4.05	
	5.25	5.13	5.34	S6	6.05	6.12	6.41	
	3.93	4.25	4.16	Mean	4.14	4.34	4.34	

TABLE 2

P x I PERFORMANCE ON 8-ITEM STIMULUS MATERIALS
MEMORY-SPAN PROCEDURE

Subjects	Exposure Duration		
	30 msec.	60 msec.	90 msec.
S1	2.00	1.78	2.18
S2	2.46	2.11	2.61
S3	1.54	1.88	1.72
S4	2.19	2.01	2.42
S5	2.26	2.57	2.43
S6	3.51	3.19	3.69
Mean	2.33	2.26	2.51