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Partial Report: Iconic Store or Two Buffers?

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ABSTRACT. Selective recall of a subset of letters from a multiletter array declines systematically with increases in the delay of the partial report cue. The issues addressed were (a) whether such a decline is due to progressive loss of location information or to systematic loss of features and (b) whether partial report is the result of a select-then-identify or an identify-then-select process. Instructing the subjects to guess or not to guess had an effect of array, displacement, and extra-array errors. Emphasizing on recall location affected both intra- and extra-array errors. The interstimulus interval manipulation had an effect on extra-array errors as well as on intra-array errors. These observations are contrary to the suggestions that intra-array errors are due to loss of location information and that extra-array errors are indicative of a joint effect on misidentification due to chance and the ratio of extra-array errors to intra-array errors. Some other results are difficult for a dual-buffer model but can readily be accounted for by the orthodox view of the iconic store.

THE INITIAL STAGE OF VISUAL PERCEPTION is generally characterized as a transient veridical representation. Some investigators have suggested that only sensory, noncategorical information such as location, shape, color, and size are available in the transient representation (Haber, 1969; Neisser, 1967; Sperling, 1960). Selective recall is achieved by choosing some parts of the veridical representation for further processing on the basis of sensory information (e.g., Sperling, 1960; Turvey & Kravetz, 1970; von Wright, 1968). This position is called the "select-then-identify" view.

However, some investigators have recently argued that *all* letters in a brief stimulus display are identified and represented in an abstract form. This is achieved by transferring the discrete features (extracted from the stimulus display) from a feature buffer to a character buffer with a character identification mechanism. Letters are selectively recalled from the character buffer by an attentional mechanism. This is the "identify-then-select" view (Campbell & Mewhort, 1980; Mewhort, Butler, Feldman-Stewart, & Tramer, 1988; Mewhort & Campbell, 1978; Mewhort, Campbell, Marchetti, & Campbell, 1981).

The initial transient visual representation is often studied with a partial-report task. A subject is shown a multi-item array and cued to recall a subset of items. To monitor the progressive decline of partial report as a function of passage of time, the partial-recall cue is presented at various delays after the offset of the stimulus, a delay called the interstimulus interval (ISI).

Partial-report performance has been found to decline systematically with increases in ISI (Averbach & Coriell, 1961; Sperling, 1960). Apologists of the select-then-identify view have explained the ISI function in terms of progressive decay of the yet-to-be-integrated features (Chow, 1985, 1986; Haber & Hershenson, 1980). On the other hand, Mewhort and his associates have suggested that the ISI function was the result of increased difficulty in locating (or "addressing") individual letters in the character buffer at longer ISIs (Mewhort et al., 1981; Mewhort et al., 1988).

Using Averbach and Coriell's (1961) partial-report task, Mewhort et al. (1981) showed their subjects a brief 8-letter array (e.g., MBZDHXLG) and then presented an arrow after a predetermined ISI. Their subjects had to recall the letter indicated by the arrow. Given the fact that the subjects had to respond on every trial, there were only two kinds of errors as follows.

Intra-Array and Extra-Array Errors

Suppose the partial-report probe is presented at the location above the fourth letter of the array MBZDHXLG: The correct response is the letter D. An intra-array error is made if the subject reports any one of the other seven letters in the array (e.g., H). An extra-array error is made if the subject responds with a letter that is not among the other seven letters of the array (e.g., F). Consider how Mewhort et al. (1981) conceptualized intra- and extra-array errors in terms of the iconic store and of the dual-buffer model.

Iconic Store and the Two Kinds of Errors

Assume that the letter string MBZDHXLG consists of 38 features (straight lines, curves, acute angles, etc.). These 38 features are represented in the feature buffer as discrete elements. Mewhort et al. (1981) argued that, if location information was lost at the feature level, it would be lost in the form of spatial displacement of individual features. Moreover, the displacement of a feature of a letter (e.g., D's curve) would not affect the rest of the features of the letter (namely, D's vertical line). Hence, to Mewhort et al., the fact that the fourth letter is probed and that the curve is displaced should not lead to an intra-array error.

The subject reported a wrong letter when the iconic representation of the probed-for letter was degraded as a result of feature displacement or decay. As the correct response of the bar-probe task consisted of only a letter, there were a total of 25 incorrect letters; 7 were possible intra-array errors and 18 were possible extra-array errors. The ratio of possible extra-array errors to possible intra-array errors (18:7 in this case) is called the *extra-intra ratio.*

Mewhort et al. (1988) suggested that, by chance, an extra-array error was more likely to occur than an intra-array error by virtue of the extra-intra ratio when misidentification occurred. This is called the *extra-intra ratio assumption.* Hence, on the basis of both the feature displacement and the extra-intra ratio assumptions, Mewhort et al. (1981) suggested that the orthodox view of the iconic store implied that (a) extra-array errors should be more numerous than intra-array errors, (b) the ISI function should be complemented by a progressive increase in extra-array errors as ISI increased, and (c) there should be no complementary relationship between partial report and intra-array errors as ISI increased.

The Dual-Buyer Model and the Two Types of Errors

Mewhort et al. (1981) suggested that, given the range of temporal parameters used, all the letters in the 8-letter array should be identified in the absence of a mask (i.e., all 8 letters were correctly represented in the character buffer). At the same time, the subjects should be more uncertain of the spatial locations of individual letters in the character buffer at longer ISIs (Campbell & Mewhort, 1980; Mewhort & Campbell, 1978; Townsend, 1973). The systematic decline of partial report was the result of transposing the position subscripts attached to the letters in the character buffer. Mewhort et al. (1981) drew the following implications from their dual-buffer model: (a) Intra-array errors should be more numerous than extra-array errors; (b) there should be a complementary relationship between partial report and intra-array errors as ISI increased; and (c) there should be no complementary relationship between partial report and extra-array errors as ISI increased.

Evidence for the Dual-Buffer Model

The partial-report performance of Mewhort et al.'s (1981) subjects declined systematically with increases in ISI under the no-mask condition. Complementing the systematic decline of partial report, intra-array errors increased systematically as ISI increased. Moreover, they were more numerous than extra-array errors. These observations are consistent with the dual-buffer model but inconsistent with the orthodox view of the iconic store, by Mewhort et al.'s (1981) reasoning. At the same time, the decline in partial report as a function of ISI was also complemented by an increase in extra-array errors in the no mask condition. This last finding is contrary to an expectation based on the dual-buffer model.

Nonetheless, on the basis of partial-report data collected under several masking conditions, as well as of some additional assumptions, Mewhort et al. (1981) attributed the functional relationship between extra-array errors and ISI to "a slow decay of identity information in the character buffer" (p. 56). Emphasizing the complementary relationship between partial-report performance and intra-array errors, they rejected the iconic store and argued in favor of a dual-buffer model, which implicated an identify-then-select process.

Iconic Store and Intra-Array Errors

It can be shown that Mewhort et al.'s (1981) data are not inconsistent with the iconic store. There is an obvious reason why the iconic store can be defended even though intra-array errors were more numerous than extra-array errors. Psychologists distinguish between short-term and long-term storage mechanisms at the theoretical level. Different testing procedures are used to study these theoretical storage mechanisms.

Baddeley (1976) suggested that the terms short-term memory and long term memory be used to refer to the two different testing procedures. Short-term store and long-term store should be used to refer to the two theoretical components of memory. Once this distinction is made, it is not difficult to see that a short-term memory task used to study the short-term store may, none theless, implicate the long-term store.

By the same token, it is important to distinguish between a task used to study the initial visual storage mechanism (namely, a partial-report task as an "iconic memory task") and the initial visual storage mechanism itself (namely, the iconic store). There is a short-term store component in a partial report task used to study the iconic store for the following reason.

A subject does not remain idle before the probe is presented in a partial report task situation. Some items are processed and transferred into the short term store before the partial-report cue is presented (Coltheart, 1980; Sperling, 1960, 1963). In the events that the subject's iconic representation is degraded by feature displacement or decay and that the subject is obliged to report a letter, a letter may be selected from the short-term store simply because it is available (this is called the *ready availability principle).* An intraarray error may be made in partial report by virtue of the ready availability principle.

Contrary to Mewhort et al.'s (1981) appeal to the extra-intra ratio, there is no self-evident reason why an obligatory response in the bar-probe task situation should necessarily result in an extra-array error. Hence, the fact that intra-array errors were more numerous than extra-array errors is not inconsistent with the iconic store.

It is ambiguous to use intra-array error as an index of loss of location information in the context of the bar-probe task. An important source of ambiguity is that Mewhort et al.'s (1981) partial report was selected on the basis of the probe's position. To do well in the task, the subject must know where the probe was. For example, a subject might recall H from MBZDHXLG because the subject thought that the letter at Position 5 was required when the probed-for letter was actually at Position 4. This task became increasingly difficult as ISI increased. This intra-array error has nothing to do with the initial visual storage mechanism (iconic store or character buffer); in other words, it is not clear whether an intra-array error is the outcome of having incorrectly identified the location of the partial-report probe (Chow, 1986) or the result of mislocation at the character-buffer level (Mewhort et al., 1981).

Iconic Store and the Extra-Intra Ratio

Although the extra-intra ratio is crucial to Mewhort et al.'s (1981) treatment of the numerosity of extra-array errors, how it works in the dual-buffer model is not clear. As a first approximation, the extra-intra ratio assumption seems to mean that an extra-array error is more likely than an intra-array error when the subject has to guess at random.'

However, it is unreasonable to assume that the subject would disregard the vertical line left behind by a degraded D when the subject was obliged to report a letter by guesswork. The subject might report B instead of Q on the basis of the vertical line when the fourth letter of MBZDHXLG was probed. This example illustrates that constructive guesswork (as opposed to random guesswork) based on fragmentary iconic representation does not necessarily lead to an extra-array error, the extra-intra ratio notwithstanding.

Strictly speaking, the likelihood of making an extra-array error in partial report depends on the number of extra-array letters (i.e., letters not used in the array in question) that are visually or acoustically similar to the letters in the stimulus array. Consider the string MBZDHXLG again. The extra-array error, N might be produced by virtue of constructive guesswork because of its visual similarity to M. The letter T might be produced because of its being acoustically similar to G when a subject relied on the ready availability principle. To the extent that this is true, that extra-array errors are more numerous than intra-array errors is not an inevitable implication of the iconic store. For the same reason, a complementary relationship between partial report and extra-array errors as a function of ISI is not incompatible with the iconic store.

The tenability of dual-buffer model can be questioned because the meaning of an intra-array error is ambiguous (Chow, 1986). That this ambiguity has been recognized does not alleviate the difficulty (Mewhort, et al., 1981; Mewhort et al., 1988). At the same time, there is no self-evident reason why the extra-intra ratio should necessarily produce extra-array errors from the perspective of the iconic store. Hence, the following two theoretical questions remain: (a) Is the systematic decline of partial report with increases in ISI due to progressive loss of features or to systematic loss of location information at the level of the veridical representation, and (b) do subjects adopt the selectthen-identify or the identify-then-select strategy in a partial-report situation?

An attempt was made to answer these questions by deriving specific experimental expectations with reference to the dual-buffer model in the context of a different partial-report task.[2] The ambiguity associated with intra-array error as index of loss of location information was reduced by *not* using the probe's position as the partial-report cue. The role of the extra-intra ratio as a determinant of extra-array errors was assessed by giving the subjects different instructions.

von Wright's (1968) Partial-Report Task

In his 1968 study, von Wright used Sperling's (1960) partial-report task. He used the size of the letters as the partial-report cue in one of his conditions. Two rows of four letters each were shown simultaneously for 100 ms. Half the letters were large, and the other half were small. One of two equally likely tones was presented at the immediate offset of the stimulus display. The subjects were to recall the large letters for a high tone and the small letters for a low tone.

An experiment similar to von Wright's (1968) selection-by-size partial report was conducted to assess the dual-buffer model.[3] This task was particularly suitable for investigating the putative difficulty associated with locating the items in the character buffer of the dual-buffer model because the partial-report cue was not the position of the cue. It eliminated the confounding between the position of the partial-report cue itself and the location of the reported letter in the character buffer in question.

Recall that, to Mewhort et al. (1988), the extra-intra ratio was important to extra-array errors in *forced* partial report. It is, hence, necessary to gauge the importance of the extra-intra ratio in order to understand the etiology of intra- and extra-array errors. This question was studied by giving the subjects different instructions.

Experimental Expectations Based on the Dual-Buffer Model

Suppose that some of the subjects in von Wright's (1968) partial-report task are given the option of withholding any response if they are not sure which letters are probed for (the NOT TO GUESS condition); other subjects must always recall three letters (the GUESS condition). To Mewhort et al. (1981), the same number of extra-array errors should be made in the GUESS and NOT TO GUESS conditions at all ISIs because the same extra-intra ratio applied to both conditions regardless of ISI.

At the same time, this manipulation of recall instruction should have no effect on intra-array errors by Mewhort et al.'s (1981) reasoning because intra-array errors are due to loss of location information in the character buffer. The recall instruction manipulation (GUESS versus NOT TO GUESS) was not directed at location information, and the extra-intra ratio had nothing to do with intra-array errors.

Suppose the subjects are given two recall modes in the context of von Wright's (1968) partial-report task. They are required to recall a selective set of letters in their correct positions in the MATRIX condition and are asked to ignore the presentation locations of the letters in recall in the ARRAY condition. This manipulation is directed at location information. Such a manipulation of recall mode should not affect extra-array errors by Mewhort et al.'s (1981) reasoning because the extra-intra ratio was the same in both the MATRIX and the ARRAY conditions, nor should the ISI manipulation affect extra-array errors because the same ratio was found at all ISIs.

More intra-array errors should be found in the MATRIX condition than in the ARRAY condition. An interaction between recall mode and ISI was expected when intra-array errors were being considered with reference to the dual-buffer model. More specifically, more intra-array errors should be made at longer ISIs in the MATRIX condition, in which location information was emphasized. At the same time, there should be no ISI effect in the ARRAY condition.

In addition to intra- and extra-array errors, displacement errors were also possible if the subjects were not obliged to report three (of nine) letters on every trial. A displacement error was made in the MATRIX condition when a letter of the probed-for size was recalled in a wrong cell of the response matrix provided.

Displacement errors were justifiably not considered by Mewhort and his colleagues (Mewhort et al., 1981; Mewhort et al., 1988) because none were possible in their partial-report task. Nonetheless, it seems reasonable to expect displacement and intra-array errors occurring equally in Sperling's (1960) partial-report task for the following reason.

Consider how location information may be lost in Mewhort et al.'s (1988) model. Attached to every identified letter in the abstract character buffer is a subscript that identified its location. A change in the subscript's value renders possible a location error. It is not inconsistent with the dual-buffer model, as it is currently presented, to assume that the probability of having the value of a letter's location subscript changed is the same for all letters in the character buffer. A probed-for letter is as likely to assume the subscript of a non-probed-for location as a non-probed-for letter is to take up the subscript of a probed-for location. Hence, displacement errors should be as numerous as intra-array errors if the dual-buffer model were true. (See the left-hand panel of Appendix 1 for the experimental expectations based on the dual-buffer model.)

Experimental Expectations Based on the Iconic Store

When partial report is based on degraded iconic representation, errors are in accordance with the ready availability principle and constructive guesswork. Whereas the ready availability assumption would bring about only intra-array errors, constructive guesswork might result in both intra- and extra-array errors.

It should follow that more intra- and extra-array errors are made under the GUESS condition than under the NOT TO GUESS condition by virtue of the ready availability principle from the perspective of the iconic store. This is expected because the subjects were obliged to always report three letters in the former condition in which the pressure to use whatever information available was greater. The need to appeal to the short-term store or to rely on constructive guesswork is greater when the iconic representation becomes more degraded. Consequently, both intra- and extra-array errors should increase with increases in ISI.

More features would have decayed at longer ISIs. However, the pressure to appeal to both the ready availability principle and constructive guesswork was greater under the GUESS and the NOT TO GUESS conditions, more so at longer ISIS. Hence, Recall Instruction x ISI interaction was expected.

The visual similarity between the eight consonants used in an array and the remaining consonants was not manipulated in this study. Given the fact that the eight letters used were chosen randomly, it seems reasonable to assume that the said similarity should be the same for the GUESS and the NOT TO GUESS conditions at all ISI levels. Consequently, no Recall Instruction x ISI interaction was expected in the case of extra-array errors.

As the iconic store is a storage mechanism, it is meaningful to identify its input, storage, and output phases (Sperling, 1963). Registration of discrete bundles of features is accomplished during the input phase of the iconic store. These bundles differ in terms of their spatial expanse if the letters differ in size. The actual location of a particular bundle of features is not a feature of the bundle itself but a property of the stimulus display as a whole. Hence, if a subject is instructed to selectively process a bundle of a certain expanse, the bundle's location is normally not processed. This state of affairs might be found in the ARRAY condition of the recall mode instruction.

The subjects were required to recall letters in their presentation position under the MATRIX condition, using a letter's expanse to decide if further processing was required. Some processing capacity is diverted to determine, as well as to store, the position of the selected letter. This additional process ing reduced the overall performance level. Hence; more intra- and extra-array errors were expected under the MATRIX condition than the ARRAY condition.

There is only one source of displacement error, namely the incorrect encoding of the location of a selected bundle of features. However, there are two sources of intra-array errors: the ready availability principle and construc tive guesswork. Hence, it seems reasonable to expect more intra-array than displacement errors in the context of von Wright's (1968) partial-report task. The experimental expectations based on the iconic store have been tabulated in the right-hand column of Appendix 1.

Also shown in Appendix 1 are the expected partial-report performances common to both the dual-buffer model and the iconic store. Partial report was expected to decline systematically with increases in ISI and to suffer more under the MATRIX condition than the ARRAY condition. No difference was expected between the GUESS and NOT TO GUESS conditions .[4] The recall order manipulation was not expected to have any effect, as it was used as a safeguard against an order effect.

Method

Subjects and Stimulus Materials

Twenty-four undergraduate students with normal or corrected-to-normal vision attending the University of Wollongong (New South Wales, Australia) participated in the experiment as paid volunteers. They were randomly divided into four groups of 6 subjects each. All received the partial-report task in the first four sessions and the whole-report task in Session 5. The four groups of subjects differed in the manner in which they recalled the letters when given the partial-report task (see the Design section for details).

The same display was used for the partial-report and whole-report tasks. Three rows of 3 letters were presented simultaneously to the subjects. The nine letters of a display consisted of letters of three different sizes, 3 letters per size.

A large letter subtended a visual angle of 52' in height and 1° in width. A medium-sized letter subtended a visual angle of 39' in height and 45' in width. A small letter subtended a visual angle of 26' in height and 36' in width.

If the entire stimulus display was filled with large letters, it would subtend a visual angle of 3° 33' both in height and in width. The large, medium, and small letters were distributed randomly among the nine cells of the display matrix. Three tones--5,000, 1,000, and 300 Hz (high, medium, and low tones, respectively)-were used as partial-report cues. The ensemble of stimulus letters consisted of all consonants except Q and Y. All letters were uppercase.

Design

A split-plot 2 x 2 x 2 x 5 factorial design was used for the partial-report task. The first two factors were between-groups factors Recall Order and Recall Instruction with two levels each (MATRIX to ARRAY and ARRAY to MATRIX and GUESS and NOT TO GUESS, respectively). The third and fourth factors were repeated-measures factors Recall Mode (whether the letters were recalled in their positions-namely, MATRIX or ARRAY) and ISI (the five levels of ISI were 0, 100, 250, 500, and 750 ms).

In view of the two between-groups factors, four groups of subjects were used. As may be seen from Table 1, the subjects in Groups 1 and 3 first recalled the designated letters in the positions they were presented in Sessions 1 through 3 and then disregarded letter positions in their recall in Session 4 (i.e., the MATRIX to ARRAY order). Groups 2 and 4 received the reverse order. These two orders of recall constituted the two levels of the first between-groups variable.

In the MATRIX condition, subjects were given a response booklet of 3 x 3 grids. Every response grid consisted of 3 rows of 3 cells. Grids reminded the subjects to recall the three designated letters in their presentation locations. Furthermore, if the subjects could not recall the letter at a probedfor location, they were to mark that location.

TABLE 1
Testing and Instruction Order Given to Four Groups of Subjects

	Group 1	Group 2	Group 3	Group 4
Session	"Guess if uncertain"	"Guess if uncertain"	"Do not guess if uncertain"	"Do not guess if uncertain"
1	PR-MATRIX	PR-ARRAY	PR-MATRIX	PR-ARRAY
2	PR-MATRIX	PR-ARRAY	PR-MATRIX	PR-ARRAY
3	PR-MATRIX	PR-ARRAY	PR-MATRIX	PR-ARRAY
4	PR-MATRIX	PR-MATRIX	PR-ARRAY	PR-MATRIX
5	WR-MATRIX	WR-MATRIX	WR-MATRIX	WR-MATRIX

Abbreviations: PR, partial report; WR, whole report.

In the ARRAY condition, subjects were given a booklet of linear response arrays. Each array was made up of 9 cells in a row. This array informed the subjects to disregard letter positions in their recall of the three designated letters and that they did not have to indicate the letter position if they could not recall a letter. Groups 1 and 2 were required to guess if they could not recall a letter. They always had to recall three letters. Groups 3 and 4, however, were instructed not to guess. Consequently, they could recall fewer than three letters (i.e., omission errors were possible). All subjects were given the wholereport task in Session 5. They had to recall as many letters in their correct positions as possible in the whole report.

Apparatus and Procedure

Stimulus displays were prepared and presented with a UNIVAC personal computer driving a Tektronix Model 608 oscilloscope via a high-speed point plotter (Finley, 1985). The oscilloscope had a P31 phosphor (green) that decayed to the minimum discernible brightness in a well-lit room in 38 Vs, a condition used in this study.[5] Timing was controlled by a programmable clock driven by the computer. The partial-report cue tones were generated with a digital-to-analog device that was also driven by the computer.

A faint dot at the center of the display indicated the onset of a trial (partial or whole report). The subjects initiated the subsequent sequence of events by pressing a key. A stimulus display of 9 letters was shown for 50 ms, followed at various ISIs by one of three tones in the case of the partial-report task. The subjects recalled the large letters if the tone was high frequency, medium letters for a medium-frequency tone, and small letters for a low-frequency tone. There was no probe tone under the whole-report condition. As soon as they could, the subjects recalled as many letters as possible in their correct positions when given the whole-report task.

There were 160 trials in a session. From Trial 11 through Trial 160, each of the 15 "ISI x Probe Tone (5 levels x 3 levels)" combinations of the partial-report task was tested 10 times; the 10 trials of each such combination were randomly distributed within the 150 experimental trials. The ISI values and probe tones used in the first 10 trials were chosen randomly. The aforementioned 15 "ISI x Probe Tone" combinations were not applicable to the whole-report condition.

Results

Partial-report superiority was not found in the first 100-trial session (Chow, 1985). Furthermore, partial report by size was more difficult than partial report by spatial location (von Wright, 1968). Hence, data from the first two sessions were not included in the present discussion. Only partial-report data from Sessions 3 and 4 were analyzed. Moreover, data from the first 10 trials of a session were discarded.

The subjects were given credit for all the letters correctly recalled, regardless of position, under the ARRAY condition. Letters recalled under the MATRIX condition were scored with the position-correct criterion (namely, that they were scored as correct only when they were recalled in their correct positions). Incorrectly recalled letters were categorized as extra-array, intraarray, or displacement errors.

All effects and interactions were significant at the .05 level.

Partial Report

To ascertain if the subjects' partial-report performance declined systematically with increases in ISI, the mean numbers of items available (Sperling, 1960) were subjected to a split-plot 2 x 2 x 2 x 5 factorial analysis of variance (ANOVA). Details on the factors were the same as those mentioned earlier in the Design Section of Methods.

This analysis revealed only three main effects for Recall Order, Recall Mode, and ISI as follows. In the case of the Recall Order effect, the subjects did better when they changed from the ARRAY mode in Session 3 to the MATRIX mode in Session 4 ($M = 4.16$) than when they changed from the MATRIX mode in Session 3 to the ARRAY mode in Session 4 ($M = 3.42$), $F(1, 20) = 7.41$, $MSe = 4.38$. As for the Recall Mode effect, recall was better under the ARRAY condition ($M = 3.99$) than the MATRIX condition ($M = 3.59$), $F(l, 20) = 10.01$, $MSe = 0.987$. The subjects' partial-report performance declined systematically with increases in ISI $F(4, 80) = 32.12$; $MSc = 0.317$. Table 2 shows the number of letters available at the five ISIS. An average of 2.95 items were recalled in the whole-report condition.

To assess the differential contributions of intra- and extra-array errors to the systematic decline of partial report as a function of ISI, these two error types were subjected to the aforementioned split-plot 2 x 2 x 2 x 5 factorial ANOVAs.

Intra-Array Errors

The analysis showed a significant main effect of Recall Instruction, F(1, 20) = 11.57, MS_e = 0.3. Also significant were the main effect of ISI, F(4, 80) = 6.58, MS_e = 0.02, and the Recall Instruction x ISI interaction, F(4, 20) = 2.69, MS_e = 0.02. More intra-array errors were made by subjects who were instructed to guess *(M* = 0.85) than by those instructed not to guess *(M* = 0.61).

TABLE 2
Mean Number of Items Available, Intra-array Errors, and Extra-array Errors
at the TWO Levels of Recall Instruction as a Function of ISI

	GUESS at ISI (ms)					NOT TO GUESS at ISI (ms)					
Measure	0	100	250	500	750	0	100	250	500	750	WR
PR	4.57	4.19	3.98	3.41	3.51	4.16	3.99	3.70	3.21	3.18	
Intra	0.75	0.79	0.88	0.94	0.90	0.62	0.55	0.60	0.66	0.62	2.95
Extra	0.39	0.44	0.47	0.49	0.53	0.26	0.28	0.30	0.33	0.34	

Abbreviations: PR, partial report; WR, whole report; Intra, intra-array errors; Extra, extra- errors.

The ISI function was not a systematic one for subjects who were instructed not to guess (Table 2). However, more intra-array errors were made at longer ISIS when the subjects were required to guess. None of the other main effects (for Recall Mode or Recall Order) or interactions were signifi- cant.

Extra-Array Errors

The analysis showed only three significant main effects at the 0.05 level for Recall Instruction, Recall Mode, and ISI. For Recall Instruction, more extraarray errors were made when the subjects had to guess *(M* = 0.46) than when they were instructed not to guess *(M* = 0.30), F(1, 40) = 4.23, *MSe* = 0.379. For Recall Mode, more extra-array errors were made under the MATRIX condition *(M* = 0.45) than under the ARRAY condition *(M* = 0.31), F(1, 40) = 8.8, MSe = 0.136. More extra-array errors were made at longer ISIS F(4, 80) = 8.19, *MSe = 0.01.* Table 2 shows the mean number of extra-array errors at the five ISIs, respectively. There was no effect of Recall Order, and none of the interactions were significant.

Displacement Errors

Displacement errors were found only in the MATRIX condition. It was possible to compare displacement errors and intra-array errors in the MATRIX condition. More intra-array errors *(M* = 0.70) were made than displacement errors *(M* = 0.37) in the MATRIX condition .[6]

When displacement errors alone were subjected to the split-plot 2 x 2 x 5 (Recall Instruction x Recall Mode x ISI) ANOVA, the main effects of Recall Instruction were significant, F(1, 20) = 5.74, *MSc = 0*.176; so was the main effect of ISI, F(4, 80) = 2.66, *MSe = 0*.027. Also significant was the Recall Instruction x ISI interaction, F(4, 80) = 2.49, *MSe = 0*.027.

More displacement errors were found in the GUESS condition (M = 0.46) than in the NOT TO GUESS condition (M = 0.28). The relationship between the mean number of displacement errors and the ISI is not a monotonic one
(Table 3).

TABLE 3
Mean Number of Displacement Errors under the GUESS **and NOT TO** GUESS **Instructions in the MATRIX Condition**

	ISI (ms)				
Recall Instruction	0	100	250	500	750
GUESS	0.44	0.42	0.37	0.58	0.48
Not TO GUESS	0.32	0.37	0.21	0.28	0.20

Discussion

A systematic decline in partial report as ISI increased was found, and there was a complementary increase in intra-array errors as well as a complementary increase in extra-array errors. As is the case with the findings of my 1986 study, the results of the present study agree with those of Mewhort et al.'s 1981 study at the empirical level. At issue are the following questions:

1. Did the systematic increase in intra-array errors as the delay of ISI increased unambiguously represent progressive loss of location information?
2. Should the complementary increase in extra-array errors as partial report decreased be ignored?
3. How does the traditional view of the iconic store fare when compared with the dual-buffer model?

To the extent that intra-array errors can be explained by the ready availability principle and that the extra-intra ratio fails to account for extra-array errors, the case for the dual-buffer model is weakened. Some aspects of the data are difficult for the dual-buffer model but consistent with the orthodox view of the iconic store.

First, a task designed to test the iconic store implicates the short-term store because the subjects would have processed some display letters before the presentation of the partial-report cue. When the subjects have to base their responses on a fading representation, they may pick some letters from among the nonselectively identified letters simply because those letters are readily available. If such a letter is not of the probed-for size, an intra-array error is made. This ready availability principle becomes more prominent at longer ISIS because the iconic representation is less useful. Consequently, the finding that more intra-array errors were found at longer ISIS is consistent with the orthodox view of the iconic store.

Second, it is assumed by the dual-buffer model that the rate at which item information is lost is too slow to be affected in the ISI ranges typically used in partial-report tasks (namely, shorter than 1 s; Mewhort et al., 1981). Hence, the number of extra-array errors was not expected to vary with ISI because extra-array errors were assumed to be unrelated to location information. The systematic increase in extra-array errors as ISI increased was unexpected and thus difficult for the dual-buffer model.

Third, subjects made more extra-array errors when required to recall three letters in their presentation positions (i.e., the MATRIX condition) than when not required to pay attention to letter positions (i.e., the ARRAY condition). This is contrary to the assumption that extra-array errors are determined by the extra-intra ratio, which is not relevant to loss of location information.

Fourth, when only the MATRIX condition was considered, there were more intra-array errors than displacement errors. This observation is inconsistent with the dual-buffer model because it should be as likely for a probedfor letter to assume a non-probed-for letter's location subscript as it is for the reverse to occur.

The fifth point is that more yet-to-be-integrated features decay at the longer ISIs in the orthodox view of the iconic store. Hence, a subject might have to guess more often for long ISIs than for short ISIs. However, the guesswork was not carried out in a void. There is no self-evident reason why guesswork should be determined by the extra-intra ratio.

The subjects might have constructed the response letters, and this construction would be based on whatever features still remained. As the expanse of a feature-bundle might be distorted by the loss of some features, it became more likely that a wrong partial feature-bundle was used in the subject's construction of a response letter. An incorrectly constructed letter might be an intra- or extra-array error, depending on what was left in a partial featurebundle as well as on the exact composition of the letter array in question. Hence, both types of errors should increase with increases in ISI. Given **the ISI** values used, the increase in extra-array errors with increases in ISI is inconsistent with the dual-buffer model in which no decay is envisaged at the level of the character buffer.[7]

That extra-array errors may reflect loss of identity information is based on the putative role of the extra-intra ratio in Mewhort et al.'s (1981) argu ment. This argument is weakened if it can be shown that the extra-array ratio has nothing to do with extra-array errors and that extra- and intra-array errors can be produced by the same principle.

The extra-intra ratio used in this experiment was 10:6. The effect of this ratio was studied with the recall instruction manipulation. The number of extra-array errors should not differ under the GUESS and the NOT TO GUESS conditions to the extent that the extra-intra ratio would have a role in determining extra-array errors. However, more extra-array errors were made under the GUESS than the NOT TO GUESS condition, suggesting that the extra-intra ratio was not responsible for extra-array errors.

The data suggest that the subjects engaged in constructive guesswork more often under the GUESS condition than under the NOT TO GUESS condition. The observed effect of recall instruction on both intra- and extra-array errors can readily be explained in terms of the iconic store. However, the effect of recall instruction on intra-array errors is difficult for the dual-buffer model because intra-array errors are assumed to be due to loss of location information. The recall instruction manipulation had nothing to do with location information.

Partial report was superior to whole report, and the partial-report superiority declined systematically with increases in ISI.[8] It is not clear how the information about letter size is represented in the character buffer without detracting abstractness from the "prepronounceable" letters, nor is it known how the information about letter size may change as ISI increases in the dual buffer model. Hence, it is not possible to envisage how the dual-buffer model (which implicates the identify-then-select assumption) may explain the partial-report superiority as well as its systematic decline with increases in ISI.

The iconic store, together with the ready availability principle and the constructive guesswork assumption, can readily account for the partial-report data. The iconic representation of the yet-to-be integrated features assumed the form of spatially distributed feature-bundles of various expanses because the letters subtended different visual angles in this experiment. Featurebundles were selected for further processing on the basis of their expanse. Location information was encoded as an appendage to an identified letter in the MATRIX condition but not in the ARRAY condition. This additional processing rendered performance lower under the MATRIX condition than under the ARRAY condition (hence, the main effect of recall mode).

All but two of the experimental expectations based on the iconic store were met. The first exception was the absence of a recall mode effect on intra-array errors when more intra-array errors were expected under the MATRIX condition than under the ARRAY condition. This unexpected outcome might be due to the following procedural feature: In order to emphasize the locations of the probed-for letters, the subjects were required to mark a location even when they could not recall a letter under the MATRIX condition. Having marked a location, subjects in Groups 1 and 2 (i.e., the two GUESS groups) under the MATRIX condition might have thought that they had completed the response requirement.

In such an event, the subjects had committed, in fact, an omission error, contrary to the GUESS requirement. This state of affairs might affect the number of intra-array errors more than the number of extra-array errors under the MATRIX condition. Hence, a recall mode effect on extra-array errors was found but not on intra-array errors.[9]

The second exception was the effect of recall order on partial report. The recall order manipulation was carried out as a control procedure because the subjects had to recall in two modes. The fact that recall order did not interact with any other factors makes data interpretation easier. Nonetheless, the direction of the recall order effect is counterintuitive.

The response mode required was more difficult in the MATRIX condition than in the ARRAY condition. More specifically, the subjects had to deal with location information in addition to item information in the MATRIX condition, but only item information was required in the ARRAY condition. The MATRIX to ARRAY groups had three sessions of practice on the more difficult recall mode before switching to an easier recall mode, whereas the ARRAY to MATRIX groups were given the more difficult recall mode after three sessions of practice on the easier recall mode. Although, on intuitive grounds, it seems reasonable to expect the MATRIX to ARRAY groups to do better than the ARRAY to MATRIX groups, the opposite was found. This counterintuitive finding may shed light on what the subjects learned in the first three sessions.

First, the subjects learned to refrain from initiating nonselective processing as soon as the stimulus was presented. This is beneficial to partial-report performance because nonselectively processing and maintaining some letters in the short-term store interfered with the maintenance of the iconic representation (Chow & Murdock, 1975, 1976). The subjects learned to refrain from doing any processing until the partial-report cue was presented. Attention was directed by the partial-report cue to the feature-bundles with the designated expanse. Individual letters were identified on the basis of whatever features which remained usable in the bundles. Hence, it was necessary to give subjects extensive practice on Sperling's (1960) partial-report task (Chow, 1985); they learned to refrain from engaging in nonselective recall.

Second, the subjects learned what to process. The MATRIX to ARRAY groups learned in the first three MATRIX sessions that, in addition to evoking an established program of motor movements necessary for naming a letter (Sperling, 1963), it was necessary to encode the letter's position as an appendage. The additional processing of location information depressed the absolute level of partial report. Moreover, the subjects found it difficult not to process the location information when they switched to the ARRAY condition in Session 4.
The ARRAY to MATRIX groups practiced in the first three ARRAY sessions on identifying the letters with no appendage of location information. They might have found it more difficult when they switched to the MATRIX condition in Session 4. However, the detrimental effect due to processing the additional location information was less severe than the effect due to the inability to refrain from encoding the unnecessary location information in Session 4 suffered by the MATRIX to ARRAY groups.

Summary and Conclusions

Chance and the extra-intra ratio jointly give rise to extra-array errors when misidentification occurs. and recalling letters from wrong positions are brought about by loss of location information in the dual-buffer model. Guesswork was manipulated through recall instruction in this study. The manipulation of recall instruction affected intra-array, extra-array, and displace ment errors. The relative importance of location information was manipulated by recall mode. The recall mode manipulation affected extra-array errors. Although these data can be readily explained by the orthodox view of the iconic store, they are inconsistent with the dual-buffer model.

It may be concluded that the systematic decline of partial report as ISI increased was due to progressive loss of features. The extra-array, intra-array, and displacement errors were due to (a) the need to construct letters on the basis of incomplete feature-bundles and (b) the ready availability of nonselectively identified letters in the short-term store. Intra- and extra-array errors do not unambiguously represent loss of location information and item information, respectively. They are the results of the joint action of the constructive guesswork and the ready availability principles because the short-term store in implicated by the partial-report task.

APPENDIX I
Experimental Expectations for Subject Error on the Basis of the Dual-Buffer Model and of the Iconic Store

Dependent variable	Dual-buffer model	Iconic store
Partial report	Lower at longer ISIs	Lower at longer ISIs
	Number in MATRIX < Number in Array	Nuumber in MATRIX < Number in Array
	Number in GUESS = Number in NOT TO GUESS	Number in GUESS = Number in NOT TO GUESS
	No Recall Order effect	No Recall Order effect
Intra-array error	More numerous at longer ISIs	More numerous at longer ISIs
	Number in MATRIX > Number in Array	Nuumber in MATRIX > Number in Array
	Number in GUESS = Number in NOT TO GUESS	Number in GUESS > Number in NOT TO GUESS
	Recall Mode x ISI interaction	Recall Mode x ISI interaction
Extra-array error	No ISI effect	More numerous at longer ISIs
	Number in MATRIX = Number in Array	Nuumber in MATRIX > Number in Array
	Number in GUESS = Number in NOT TO GUESS	Number in GUESS > Number in NOT TO GUESS
Displacement error	Number of displacement errors = Number of intra-array errors	Number of displacement errors < Number of intra-array errors

REFERENCES

Averbach, E., & Coriell, A. S. (1961). Short-term memory in visicon. *Bell System Technical Journal, 40,* 309-328.

Baddeley, A. D. (1976). *The psychology of memory.* New York: Basic Books.

Campbell, A. J., & Mewhort, D. J. K. (1980). On familiarity effects in visual information processing. *Canadian Journal of Psychology, 34,* 134-154.

Chow, S. L. (1985). Iconic store and partial report. *Memory & CognWon, 13,* 256-264.

Chow, S. L. (1986). Iconic memory, location information, and partial report. *Journal of Experimental Psychology: Human Perception and Performance, 12,* 455-465.

Chow, S. L. (1987a). Iconic memory or icon? *Behavioral and Brain Sciences, 10,* 313-315.

Chow S. L. (1987b). Science, ecological validity, and experimentation. *Journal for the Theory of Social Behavior, 17,* 181-194.

Chow, S. L., & Murdock, B. B., Jr. (1975). The effect of a subsidiary task on iconic memory. *Memory & Cognition, 3,* 678-688.

Chow, S. L., & Murdock, B. B., Jr. (1976). Concurrent memory load and the rate of readout from iconic memory. *Journal of Experimental Psychology: Human Perception and Performance, 2,* 179-190.

Coltheart, M. (1975). Iconic memory: A reply to Professor Holding. *Memory & Cognition, 3,* 42-48.

Coltheart, M. (1980). Iconic memory and visible persistence. *Perception & Psychophysics, 27,* 183-288.

Dick, A. O. (1971). On the problem of selection in short-term visual (iconic) memory. *Canadian Journal of Psychology, 25,* 250-263.

Finley, G. (1985). A high-speed point plotter for vision research. *Vision Research, 25,* 1993-1997.

Garner, W. R., Hake, H. W. & Eriksen, C. W. (1956). Operationalism and the concept of perception. *Psychological Review, 63,* 149-159.

Haber, R. N. (Ed.). (1969). *Information-processing approaches to visual perception.* New York: Holt, Rinehart and Winston.

Haber, R. N. (1983). The impending demise of the icon: A critique of the concept of iconic storage in visual information processing. *Behavioral and Brain Sciences, 6,*1-11.

Haber, R. N., & Hershenson, M. (1980). *The psychology of visual perception* (2nd ed.). New York: Holt, Rinehart and Winston.

Holding, D. (1970). Guessing behavior and the Sperling store. *Quarterly Journal of Experimental Psychology, 22,* 248-256.

Holding, D. (1972). Brief visual memory of English and Arabic letters. *Psychonomic Science, 28,* 241-242.

Holding, D. (1975). Sensory storage reconsidered. *Memory & Cognition, 3,* 31-41.

Kahneman, D. (1968). Method, findings, and theory in studies of visual masking. *Psychological Bulletin, 70,* 404-425.

Manicas, P. T., & Secord, P. F. (1983). Implications for psychology of the new philosophy of science. *American Psychologist, 38,* 399-413.

Meehl P. E. (1978). Theoretical risks and tabular asterisks: Sir Karl, Sir Ronald, and the slow progress of soft psychology. *Journal of Consulting and Clinical Psy chology, 46,* 806-834.

Merikle, P. M. (1980). Selection from visual persistence by perceptual groups and category membership. *Journal of Experimental Psychology: General, 109,* 279-295.

Mewhort, D. J. K. (1967). Familiarity of letter sequences, response uncertainty, and the tachistoscopic recognition experiment. *Canadian Journal of Psychology, 21,* 309-321.

Mewhort, D. J. K. (1987). Information stores and mechanisms: Early stages of visual processing. In H. Heuer & A. F. Sanders (Eds.), *Perspectives on perception and action (pp.* 335-357). Hillsdale, NJ: Erlbaum.

Mewhort, D. J. K., Butler, B. E., Feldman-Stewart, D. & Tramer, S. (1988). "Iconic memory," location information, and the bar-probe task: A reply to Chow. *Journal of Experimental Psychology: Human Perception and Performance, 14,* 729-737.

Mewhort, D. J. K., & Campbell, A. J. *(1978).* Processing spatial information and the selective-masking effect. *Perception & Psychophysics, 24,* 93-100.

Mewhort, D. J. K., Campbell, A. J., Marchetti, F. M., & Campbell, J. I. D. *(1981).* Identification, localization, and "iconic memory": An evaluation of the bar-probe task. *Memory & Cognition, 9,* 59-67.

Neisser, U. *(1967). Cognitive psychology.* New York: Appleton-Century-Crofts.

Sperling, G. *(1960).* The information available in brief visual presentations. *Psychological Monographs, 74 (11,* Whole No. *498).*

Sperling, G. *(1963).* A model for visual memory tasks. *Human Factors, 5, 19-31.*

Townsend, V. M. *(1973). Loss* of spatial and identity information following a tachistoscopic exposure. *Journal of Experimental Psychology, 98, 113-118.*

Turvey, M. T., & Kravetz, S. *(1970).* Retrieval from iconic memory with shape as the selection criterion. *Perception & Psychophysics, 8, 171-172.*

von Wright, J. M. *(1968).* Selection in visual immediate memory. *Quarterly Journal of Experimental Psychology, 20, 62-68.*

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Footnotes

[1] Mewhort et al. (1988) were more specific as to how the extra-intra ratio might work when they said, ". . . if subjects misidentify a letter, chance favors report of an extra-array item over an intra-array item by 18:7" (p. 729). Be that as it may, still it is necessary to know what process underlies a misidentification, which is susceptible to the influence of chance, before the extra-intra ratio assumption can be assessed. Given the facts that Mewhort et al.'s (1981) subjects must report a letter on every trial, given that they emphasized on the joint contribution of the extra-intra ratio and chance, guesswork is not inconsistent with the process which underlies their misidentification.

[2] Mewhort et al. (1981) established the dual-buffer model with Averbach and Coriell's (1961) bar-probe task; Sperling's (1960) partial-report task was used in this study. This raises the metatheoretical question of whether it is proper to test a theoretical model based on one task with a different task. The answer to this question depends on what the dual-buffer is used for, not on how it is established in the first place. It is improper to do so if the model is meant to be used specifically and exclusively for Mewhort et al.'s (1981) bar-probe task. However, that is not the case; the model is meant to be a general one.
The dual-buffer model is often compared with the traditional iconic store. The feature and character buffers under discussion are two indispensable components of a model meant to be applied to diverse phenomena. The model is one about the initial stages of visual information processing in general (Mewhort, 1987). The proper way to test a theory implicating an unobservable structure or mechanism is to carry out a series of converging operations (Chow, 1987b; Garner, Hake, & Eriksen, 1956). An essential feature of conducting converging operations is to test the theory of interest with various tasks; in other words, it is proper to test a general theory with a task that is different from the task originally used to establish the general theory.

[3] Some investigators consider it inappropriate to use Sperling's (1960) partial-report task to study the veridical representation at the initial stage of visual information processing for various reasons (see, e.g., Dick, 1971; Holding, 1970, 1972, 1975; Merikle, 1980). For example, the partial-report superiority may be found suspect on the ground that whole report suffers from more output interference than partial report. These criticisms of Sperling's (1960) task have been answered (Chow, 1985; Coltheart, 1975, 1980). More specifically, output interference cannot explain the systematic decline of partial-report superiority as ISI increases (Coltheart, 1975). Moreover, partial-report superiority was not found when the partial-report cue was category membership (Chow, 1985). This issue is hence not considered here.
Some investigators found the measure "number of items available" artificial. As has been pointed out by Coltheart (1980), this measure is a valid one as long as the set of partial-report cues (high, medium and low tones in the present study) are used equally often in a random order in the course of a session. This procedure was followed in the present study.
Some investigators dismissed the iconic store on the grounds that our knowledge about the putative store was based on experimental data obtained with an artificial task (namely, a partial-report task) in an artificial setting (namely, very brief stimulus presented with a tachistoscope in a laboratory). The iconic store is said to lack ecological validity (see, e.g., Haber, 1983). Underlying this "ecological validity" critique of the iconic store is the metatheoretical assumption that the experimental task used to study a phenomenon must mimic the phenomenon itself. Chow (1987a, 1987b) has show that this assumption is incorrect.

[4] More numerous intra- and extra-array errors were expected under the GUESS and NOT TO GUESS conditions from the perspective of the iconic store. This expectation is, nonetheless, consistent with the expectation that there was no difference due to recall instruction in terms of partial report because omission errors were possible ii =he NOT TO GUESS condition, not the GUESS condition.

[5] The P31 phosphor has a relatively slow decay rate. Would this invalidate the present study? A negative answer can be offered for the following reasons. First, *informational* and *visible* persistence have been shown to follow different time courses, and the former is not sensitive to light energy per se (Coltheart, 1980). Second, the relatively lengthy persistence of P31 phosphor would be a problem for a psychophysical exercise concerned with the absolute value of *visible* persistence. The present study deals with relative *informational* persistence under different conditions. Third, care was taken to conduct the study in a well-lit room. No subject reported seeing an afterimage. Fourth, the present pattern of data agrees with Mewhort et al.'s (1981) data under the no-mask condition (namely, the systematic decline of partial report and the systematic increase of intra-array errors as ISI increased). Fifth, the relatively long phosphor persistence should make it more difficult to replicate the typical systematic decline of partial report and make it more difficult to have the complementary error functions. In sum, using P31 phosphor does not invalidate the data reported in this study.

[6] In the case of the MATRIX condition, whether an intra-array error was made at the correct position was ignored. It was counted as an intra-array error.
Intra-array and displacement errors in the MATRIX condition were subjected to a split-plot 2 x 2 x 2 x 5 (Recall Instruction x Recall Order x Type of Spatial Error x ISI) ANOVA. The two levels of Type of Spatial Error were intra-array and displacement errors. The first two factors were between-groups factors, and the last two were within-subjects factors. Given the purpose of this analysis, only the main effect of Type of Spatial Error and the interactions implicating Type of Spatial Error are meaningful. Only the main effect

of Type of Spatial Error was significant, F(1, 20) = 170.69, MS. = 0.039. Type of Spatial Error did not interact with any other factors.

[7] This argument is based on the assertion, ". . . the decline in accuracy should be complemented by an increase in location errors, not, as implied by the fading-image metaphor, by an increase in item errors" (Mewhort et al., 1981, p. 53).

[8] To establish that there was partial-report superiority, the whole-report condition was treated as an extra level of the ISI factor. Consequently, a split-plot 2 x 2 x 2 x 6 (Recall Order x Recall Instruction x Recall Mode x ISI) ANOVA was, conducted. The main effect of ISI of this analysis was significant, F(5, 100) = 22.97, MSe = 0.357. Table 2 shows the means.

[9] The sum (partial report)/3 + intra-array errors + extra-array errors, shown under the GUESS condition in Table 2 should be 3 for all ISIS; however, the sums were 2.66, 2.63, 2.68, 2.57 and 2.60 for ISI of 0, 100, 250, 500, and 750 ms, respectively. These departures may be due to the procedure feature described here.