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Identification, localization, and "iconic memory": An evaluation of the bar-probe task

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The partial report tachistoscopic task has been used to define "iconic memory," a labile image-like precategorical visual store. Six interrelated partial report studies are reported that challenge the construct. On each trial, subjects were shown an eight-letter pseudoword (representing one of four orders of approximation to English) and a bar probe indicating which letter to report. The probe was delayed systematically, and the experiments included both mask and no-mask conditions. All three variables—familiarity of the material, masking, and delay of the probe—affected accuracy of report. Delaying the probe, for example, reduced accuracy by increasing location errors. Delaying the mask increased accuracy by reducing both location and item errors, but it did not reduce the location errors until its effect on item errors had reached asymptote. Across the stimulus array, however, masking reduced accuracy at all delays by increasing location errors. Finally, the greater accuracy associated with higher orders of approximation to English was complemented by a decrease in item errors, but the familiarity factor had no effect on location errors. Taken together, even though the task has been used to define the idea, the results indicate that the bar-probe task cannot be explained in terms of a simple iconic memory concept. Instead of a simple image-like buffer, the explanation requires a feature buffer, an "intelligent" letter identification process, and a postidentification character buffer. Iconic memory is a construct that oversimplifies the information processing system used in the bar-probe task.

In a partial report bar-probe task, subjects are shown a row of letters followed by a bar marker indicating which letter to report. Accuracy of report usually takes a W shape across the stimulus row, and delaying the probe reduces accuracy. While masking reduces accuracy of report, particularly report from the middle items, delaying the mask increases overall accuracy (e.g., Averbach & Coriell, 1961; Merikle & Glick, 1976).

In a recent paper, Campbell and Mewhort (1980) have suggested an information processing account of the bar-probe task (see also Mewhort & Campbell, 1978). Their account involves two data buffers, a feature-level buffer and a character-level buffer. In addition, their account includes two processing mechanisms, a character identification mechanism and an attentional search mechanism.

In contrast to the multiprocess analysis, the bar-probe task is commonly associated with a single-buffer account based on the idea of a sensory register. The sensory register—named, by various authorities, iconic memory, visual information store, sensory information store, or very short-term visual memory—is usually described as a labile image-like memory that holds precategorical feature information (e.g., Dick, 1974, p. 592; Lindsay & Norman, 1977, pp. 310-315; Neisser, 1967, Chapter 2). The loss associated with a delay of the partial report cue is thought to reflect loss from the register (i.e., to reflect a fading image).

The two accounts of the bar-probe task offer very different explanations of performance, and the present experiments were designed to contrast their implications. The contrasts involve two main manipulations, a delay-of-probe and a masking manipulation. In addition, the experiments include a manipulation of the familiarity of the material. To explain the rationale for the experiments, we shall consider the dual buffer model in some detail and then contrast predictions derived from the two accounts.

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Dual Buffer Model

Tracing the events on a trial in the bar-probe task, Campbell and Mewhort (1980) start their analysis at a feature level and suggest four distinct com-

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ponents, each related to one of the buffers or processing mechanisms.

(1) Features extracted from the stimulus array are stored in the feature buffer. The feature representation is precategorical, and the buffer's capacity is unlimited; that is, the buffer preserves spatial and other physical attributes of the display. Thus, the feature buffer holds raw data concerning the shape of each letter; for example, different features would be involved in upper- and lowercase letters.

(2) The data held in the feature buffer are used by the character identification mechanism. The latter combines information about a character's shape with letter frequency information. The shape information is taken from the feature buffer, and the letter frequency information is taken from a memory contained within the identification mechanism. The combination algorithm is thought to involve a Bayesian decision rule (as suggested by Hanson, Riseman, & Fisher, 1976).

To obtain shape information, the character identification mechanism must sort the features into appropriate bundles. A failure to sort correctly would mix features from adjacent items, and such an amalgam would lead to an incorrect response (for reasons described later, it is likely to be an item error). Treisman and Gelade (1980) describe characteristics of a feature integration process similar to that undertaken by the character identification mechanism.

Frequency information represents a relatively low-level use of orthographic knowledge. As noted later, the use of extrafrequency information (i.e., the orthographic rules described by Venezky, 1970) is associated with a mechanism that follows letter identification; Campbell and Mewhort (1980) have shown that, while it is used in related tasks, the latter mechanism is not used in the bar-probe task. Nevertheless, it is not clear how much sequential constraint the frequency information involves; single-letter frequency information is too weak, and quatragram information is too strong.

The letter identification mechanism produces an abstract representation of each character, a process that involves data reduction. To the extent that some information is present at the feature level but is not represented in the abstract code, one may describe the identification mechanism as a "selective" process. Such a description should not be confused with the more traditional idea of a spatial selection based on a "searchlight" selective attention analogy; the identification process is not selective in the sense that it works on some feature bundles at the expense of others.

(3) The output from the character identification mechanism is stored in the second buffer, the character buffer. The character buffer stores an abstract representation of the material; it is postcategorical, but it preserves the relative spatial position of the letters. Also, the buffer absorbs time-of-arrival differences associated with delays produced by processes prior to it. In the latter role, of course, the buffer shares a characteristic common to buffers in any real-time information processing system.

The idea of a feature analysis is well accepted. The idea of a character buffer may, however, be contentious. Posner, Boies, Eichelman, and Taylor (1969) popularized the distinction between a physical (feature) representation and a name representation. Their account left little room for an intermediate representation. The character buffer, however, has properties of both their physical and name codes. Like the feature representation, it preserves relative spatial position; like the name code, it is more abstract than an image-like featural representation. Nevertheless, the character buffer does not entail the name in the sense of a pronunciation code, a characteristic we associate with short-term memory. Thus, the Posner et al. well-known distinction contrasts the physical and the short-term memory representation, whereas Campbell and Mewhort (1980) impose extra stages between those levels.

The justification for the extra stages is threefold. First, the character buffer provides a postidentification representation and, as such, provides a theoretically convenient interface between letter identification and processes associated with construction of supraletter units in word identification, a point to be elaborated later (see also Smith & Spoehr, 1974, pp. 259-260). Second, the buffer provides a post-feature, but still spatial representation, and, as Campbell and Mewhort (1980) have shown, such a representation is needed to explain the separate familiarity effects associated with the bar- and digit-probe partial report tasks. Third, the character buffer provides the kind of representation required for integration of information across saccades. In a series of elegant studies, Rayner, McConkie, and Zola (1980) have demonstrated that information across saccades is held in a nonimage postidentification form (see also McConkie & Zola, 1979). Further, the representation is prepronounceable and preserves the relative ordering of letters.

(4) Finally, the attentional mechanism finds an item in the character buffer by using the probe as a spatial instruction and transfers the item to short-term memory for storage until report. The accuracy of selection, presumably, depends on the number of items. Channel capacity for linear resolution is about 3 bits (Garner, 1962, pp. 68-69). Thus, for an eight-letter display, selection will involve location errors, and failures of precise location should result in report of items adjacent (or close) to the item probed.

Mewhort and Campbell (1978) showed that the bulk of the errors in the bar-probe task reflect addressing problems (i.e., location errors produced at the character-buffer level). Further, presenting words for a duration clearly adequate to ensure their identification, they showed that introducing a mask increases addressing errors and suggested that, in addition to any effects at the feature-buffer level, masking disrupts spatial information at the character buffer.

The dual buffer account makes a strong distinction between spatial and identity information. A similar distinction has been made by previous authorities (e.g., Dick, 1969; Di Lollo, 1977; Townsend, 1973). Dick (1969), for example, distinguished spatial from identity information and argued that spatial information is lost faster than identity information, a position endorsed by Townsend.[1] In contrast to the present conception, however, the earlier work did not distinguish spatial information at the feature level from that at the letter level. The feature/letter separation, of course, is implied by the architecture of the dual buffer system.

The failure to distinguish spatial information at the two levels confuses within- and between-bundle spatial shifts. At the feature level, a letter is a bundle of features, and, if features lose their correct position, one would expect difficulty in identification (cf. Wolford, 1975). A transposition of complete feature bundles would, of course, yield a location error. While some features of a letter may shift (and subsets of adjacent letters may be transposed), it seems unlikely that features of adjacent letters could transpose themselves completely. Instead, letter transpositions likely reflect suprafeature spatial information (i.e., postidentification information at the character buffer).

The dual buffer account for the bar-probe task represents the "front end," the letter identification component, of a model of word identification (Mewhort & Beal, 1977; Mewhort & Campbell, 1980). In a word identification task, instead of using the attentional mechanism to search a particular position, subjects use a different mechanism (called the scan-parse mechanism) to transfer data from the character buffer to short-term memory. The latter mechanism uses an extensive repertoire of orthographic rules to derive supraletter units. The units are often syllables, but, as the units reflect an interaction of the rules with the character string, other units are also possible. The scan-parse mechanism passes the derived units to short-term memory in a left-to-right order and, thereby, converts the material from a spatial to a temporal form. The ordering provides organization for rehearsal and for sequential report of letters from pseudowords (Mewhort, 1974). In addition, the temporal form is thought to be required for lexical access and pronunciation mechanisms (Mewhort & Marchetti, Note 1).

Delay of the Probe

In the probe task, responses can be correct or can be one of two kinds of error. Item (intrusion) errors occur when subjects report a letter other than one shown on the trial. Location (inversion) errors occur when subjects report an item shown on the trial other than the letter indicated by the probe.[2]

Suppose that the loss associated with a delay of the probe reflects decay from an image-like precategorical memory. Decay of the image, presumably, means a loss, shift, or blur of the features composing the image. If the loss of functional feature data explains the decline in performance, the subjects' errors should also reflect the same process; that is, the errors should reflect the putative state of the image.

To illustrate the point, suppose that the display included an E. If the middle line segment were lost, the remaining features would resemble a C. Similarly, if the lower segment were lost, the remaining features would yield an F. The subject's response, presumably, reflects the features that remain. Thus, for the two illustrations of inaccurate feature information, the subject should respond "C" and "F," respectively.

Given a small stimulus array, for example, eight letters chosen randomly, the pool of potential item errors (18 of 25 with an eight-letter display) is larger than the pool of potential location errors (7 of 25). Consequently, loss of feature information should lead to more item than location errors. Thus, if the decrease in performance associated with a delay of the probe reflects a loss of feature information, as the iconic memory account implies, the decrease should be accompanied by a corresponding increase in item errors.

The prediction of an increase in item errors associated with the metaphor of a fading image is based on feature-level (i.e., subletter) units. The same prediction follows for any account that involves subletter units and permits the units to shift in position, to disappear, or to be transformed into other units. Thus, the prediction is not tied to a fading-image metaphor but applies also to other metaphors, for example, models based on subletter visual channels (Bjork & Murray, 1977; Breitmeyer, 1980; Santee & Egeth, 1980).

Assuming no mask is presented, the metaphor of a fading image predicts (1) that item errors should exceed location errors and (2) that correct reports should complement item errors as the cue is delayed. In contrast, the dual buffer account suggests that identification reflects the status of the feature buffer, whereas localization reflects spatial factors at the character buffer. Given a no-mask condition, identification should be excellent; nevertheless, difficulty with localization remains. As a result, essentially all errors should be errors of localization. Thus, item errors should be rare, certainly less frequent than location errors. Further, when accuracy of report declines as the probe is delayed, the loss should reflect increasing spatial uncertainty at the character buffer, not a loss of letters or of preletter feature information. As a result, 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.

The focus on location errors is supported by two main observations. Townsend's (1973) results imply a complementary relation between correct reports and location errors as the cue is delayed.[3] Mewhort and Campbell (1978; also Campbell & Mewhort, 1980, Experiment 1) showed a complementary relation between correct reports and location errors across the stimulus array. Unfortunately, there is a gap in the empirical support: Townsend did not document the relation between correct reports and location errors across the stimulus array (also, the relation was not reported in the thesis on which her published work was based; see Townsend, 1970). Mewhort and Campbell based their arguments on the tradeoff between correct reports and location errors across the stimulus array, but they did not delay the cue. Thus, we have data for both accuracy and errors across the stimulus array and for both accuracy and errors across cue delay, but we do not have data for the two manipulations together.

Masking

Discussions of masking usually focus on identification processes and on feature analysis, in particular. In general terms, masking is thought to reduce accuracy of report by disrupting feature information or by disturbing the use of that information. (Some theorists prefer to discuss visual "channels," but, as the two refer to precategorical data from which letters can be constructed, the terminology does not change distinctions important to our discussion.) In the sensory-register account, masking reduces performance by changing the raw (precategorical) data, that is, by altering the image or by impairing its use.

Recall that the sensory-register account implies that delaying the cue reduces accuracy by permitting the image to decay. Thus, the sensory-register account suggests that both masking and delaying the cue reduce accuracy by affecting feature information. Because both manipulations lead to a loss of feature information, masking should yield results qualitatively similar to those produced by delaying the probe. Thus, both manipulations should reduce performance by increasing item errors.

Suppose that a mask were to be combined with a delayed cue. Because both manipulations are thought to affect the usefulness of the sensory register in a similar way, the mask should accelerate the loss of information; that is, the mask should reduce accuracy to the asymptotic level associated, in a no-mask case, with a lengthy delay of the cue. Thus, with the cue following immediately after the target, masking should reduce accuracy and yield errors similar to those in a no-mask case involving a long delay of the cue.

According to the dual buffer account, in contrast, a mask may affect the feature buffer, the character buffer, or both. At the feature buffer, by disturbing the data used during letter identification, the mask should reduce accuracy by increasing item errors. Thus, the effect at the feature level is, essentially, the same as that postulated for the sensory-register account.

At the character-buffer level, the mask is thought to increase spatial uncertainty. If subjects lose spatial information, location errors should increase. As noted by Mewhort and Campbell (1978), however, the increase should be minimal at the natural spatial anchors: the ends, and to a lesser extent, the center (fixation) of the display.

While both identification and localization are subject to masking, there is no reason to suspect they are equally sensitive to a particular mask. A mask may well affect localization, for example, with delays at which it does not affect identification. Suppose that a mask can affect the character buffer at delays too long to affect the feature buffer; as the mask is delayed, item errors should reach asymptote faster than location errors. Thus, unlike the sensory-register account, because a mask can have different effects at the two buffers, the dual buffer account does not require qualitatively similar results for masking and delaying the probe.

METHOD

The experiments involved six groups of subjects. Each group received the same stimuli and general procedure; the differences among the groups concern the temporal relations of the probe, the mask, and the target. The first four groups constituted one experiment; the remaining two groups were added later.

Subjects

The subjects in all six groups were undergraduate students enrolled in psychology courses at Queen's University. All reported normal or corrected-to-normal vision.

Apparatus and Material

The materials were 160 eight-letter pseudowords. The pseudowords included 40 examples each of zero-, second-, and fourth-order approximations to English and were taken from lists provided by Hirata and Bryden (1971, Table 6). An additional 40 sequences were generated. The latter, called negative second-order material, were constructed using the letter frequency norms provided by Mayzner and Tresselt (1965). The position in the frequency norms was noted for each letter in the second-order materials; the rank order of the frequency table was inverted, and the negative second-order sequences were obtained by substituting letters in the second-order sequences with letters from the corresponding position in the inverted frequency table. The negative second-order materials have the same amount of sequential constraint, but, because they minimize the occurrence of high-frequency letters, are much less familiar than the zero-order pseudowords.

The stimuli were displayed on a Tektronix point-plot display monitor (Model 604) supplied with P4 phosphor and controlled by a PDP/8-e computer. Mewhort (1978) has described details of the display algorithm. The monitor was housed in a partially darkened room adjacent to the room housing the computer.

Each letter was presented in uppercase and was defined in a 5 by 7 matrix. The mask character involved all 35 dots in the matrix, and the mask stimulus involved eight such characters positioned to cover the eight letters. The probe, a full character in size, was an arrow composed of a single column of dots with two three-dot fins extending at 45 deg and 135 deg from the bottom.

The monitor's screen subtended a visual angle of about 8 deg 5 min (horizontal) x 6 deg 18 min (vertical). Each character subtended a maximum angle of about 15 x 21 min, and each pseudoword subtended an angle of approximately 3 deg 6 min x 21 min. The probe was presented about 18 min above the center of one of the letter positions.

Procedure

On each trial, a fixation dot appeared at the center of the monitor. When ready, the subject pushed a button to initiate the display sequence.

The instructions were common to all conditions. The subjects were requested to report the letter indicated by the probe, and a response was required on each trial. In addition, the nature of the materials was explained. Before starting the experiment, each subject received 30 practice trials with stimuli not used in the experiment proper.

Each of the six groups of subjects received conditions differing in the timing of the display, the probe, a mask, or some combination of these factors. Figure 1 illustrates the conditions schematically.

Condition 1. The group involved 14 subjects. The target duration was 30 msec, and the probe appeared for 30 msec. The interstimulus interval (ISI) between the target and the probe was 0, 40, 80, 120, or 160 msec. There was no mask in the experiment. The condition represents a replication of the Averbach and Coriell (1961) procedure.

Condition 2. The group involved 14 subjects. As in the first condition, the target duration was 30 msec, the probe appeared for 30 msec, and the ISI between the target and the probe was 0, 40, 80, 120, or 160 msec. In addition, the mask appeared concurrently with the probe. Finally, Condition 2 was the only condition in the experiment that contained both a mask and an ISI between the target and probe greater than zero.

Condition 3. The group involved 14 subjects. As in the second condition, the probe and the mask appeared concurrently for 30 msec and were presented immediately following the target (0-msec ISI between the target and probe-mask combination). The target duration was 30, 70, 110, 150, or 190 msec. The target duration was arranged to yield stimulus-onset asynchronies (SOAs) between the target and the mask equivalent to those in the second condition.

Condition 4. The group involved 14 subjects. As in the second condition, the target, the probe, and the mask all appeared for 30 msec. The probe always appeared immediately after the target (i.e., with a 0-msec ISI). The mask appeared 0, 40, 80, 120, or 160 msec after the target. For the 0-msec ISI between the target and the mask, the fourth condition was identical to the second and third.

Condition 5. The group involved eight subjects. The target and mask were presented for 30 msec. The mask appeared 0, 40, 80, 120, or 160 msec after the target; the probe appeared immediately after the target (0-msec ISI) and remained for 190 msec.

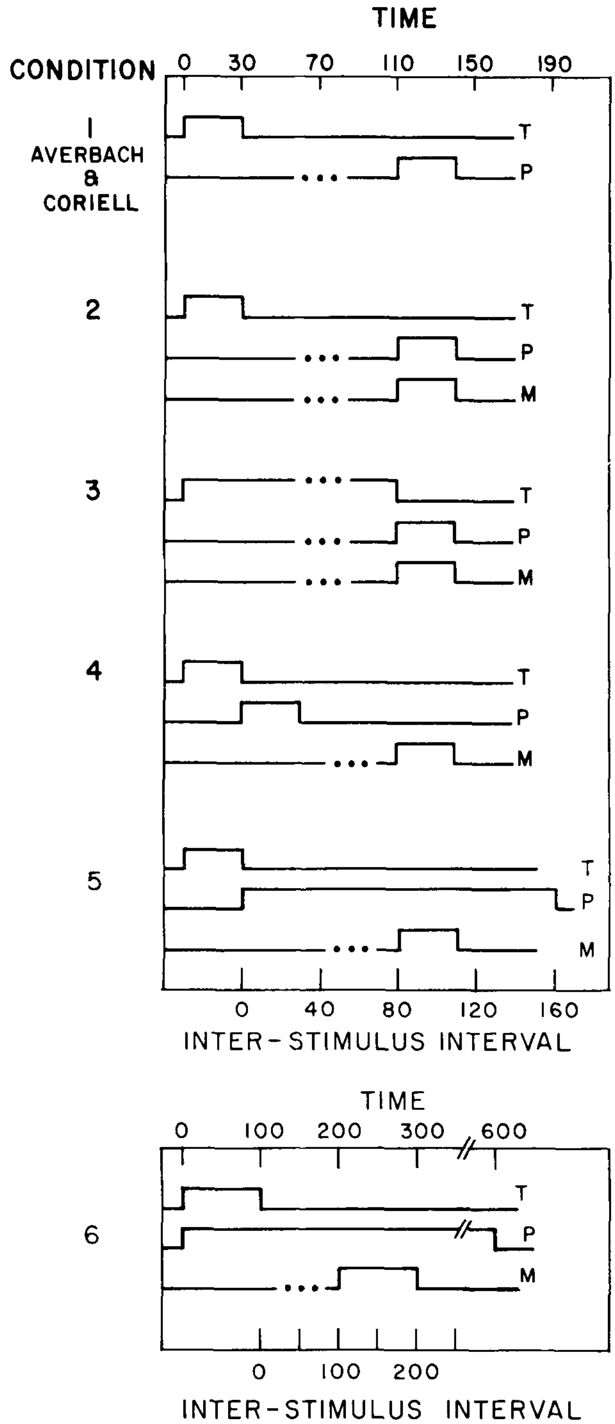

Figure 1. The figure shows the timing of events on a representative trial in each condition. The labels T, P, and M refer to target, probe, and mask, respectively. The dots indicate those timings that vary for other cases within the condition.

Condition 6. The group involved 18 subjects. The target and the mask appeared for 100 msec. On one-fifth of the trials, the mask was not presented (∞ ISI between the target and the mask). On the remaining trials, the ISI between the target and the mask was 0, 50, 100, or 150 msec. Thus, the SOAs were 100, 150, 200, and 250 msec, values considerably larger than in the earlier conditions. Finally, the probe was concurrent with the target and remained for an additional 500 msec.

Design

Each subject received 320 trials, two replications for the factorial combination of four approximations to English, eight probe positions, and five probe, or probe-mask, timings. Each pseudoword was used twice with each subject, and the order in which conditions were administered was randomized independently for each subject.

A comment concerning our comparisons among the groups is in order. Conditions 1 and 2 enable a mask/no-mask comparison across the ISI, familiarity, and probe-position variables. Conditions 2 and 3 illustrate the effect of target duration (confounded, for technical reasons, with a minor effect of target luminance).[4] Conditions 4 and 5 consider the effect of the probe's duration. Conditions 1, 2, and 4 yield, in combination, the effect of probe delay under both mask and no-mask conditions. Finally, Condition 6 provides a range of relatively large SOAs.

RESULTS

The responses were scored as correct or incorrect, and the errors were classified as either item (intrusion) or location (inversion) errors. Figures 2 and 3 summarize the data. Figure 2 shows both correct reports and errors as a function of delay of the probe and/or the mask, depending on the display condition. Figure 3 shows the same data, collapsed across the delay factor, as a function of probe position.

The No-Mask Condition

As is shown in Figure 2 (top left), delaying the probe reduced accuracy substantially [$F(4,52) = 32.86$, $p < .001$]. The decrease in accuracy of report replicates Averbach and Coriell (1961) and provides prima facie evidence for the idea of a decaying image. The decrease was complemented by an increase in location errors [$F(4,52) = 17.87$, $p < .001$], replicating Townsend (1973). Finally, there was a small, but significant, increase in item errors as the probe was delayed [$F(4,52) = 3.02$, $p < .05$].

Across the probe positions, correct reports assumed a W shape (see Figure 3, top left) and location errors took the complementary M shape. The quartic trends were highly significant for both dependent measures [$F(1,13) = 184.69$, $p < .001$, for correct reports, and $F(1,13) = 92.67$, $p < .001$, for location errors]. The tradeoff of correct reports with location errors across the array replicates the pattern shown by Campbell and Mewhort (1980, Experiment 1) and by Mewhort and Campbell (1978), but, while the tradeoff is dramatic, it was not perfect: Item errors were relatively more frequent at the ends of the array than in the middle [$F(7,91) = 16.13$, $p < .001$].

The complementary pattern of correct reports and location errors across probe positions illustrates that localization represents a major limitation to performance. A similar complement between correct reports and location errors across probe delays (Figure 2, top left) also confirms the importance of

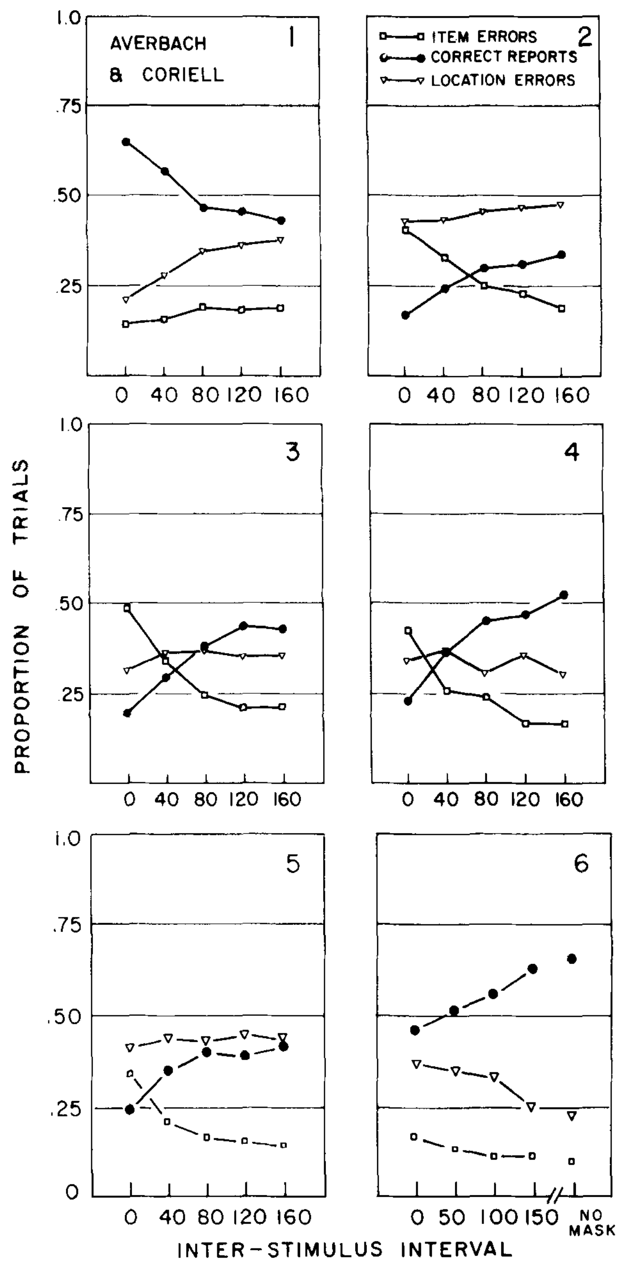

Figure 2. Accuracy of report, location errors, and item errors as a function of ISI/SOA and display condition. The conditions are numbered as in Figure 1.

localization processes. Further, the latter pattern is the reverse of that expected from the sensory-register idea. For the latter account, the decline in accuracy associated with a delayed probe is thought to reflect the loss of feature information. If delaying the probe reveals such a loss, however, it should have produced a corresponding increase in item errors. Instead, the delay produced an increase in location errors, a pattern reflecting an increased difficulty with precise localization rather than a decay of feature information.

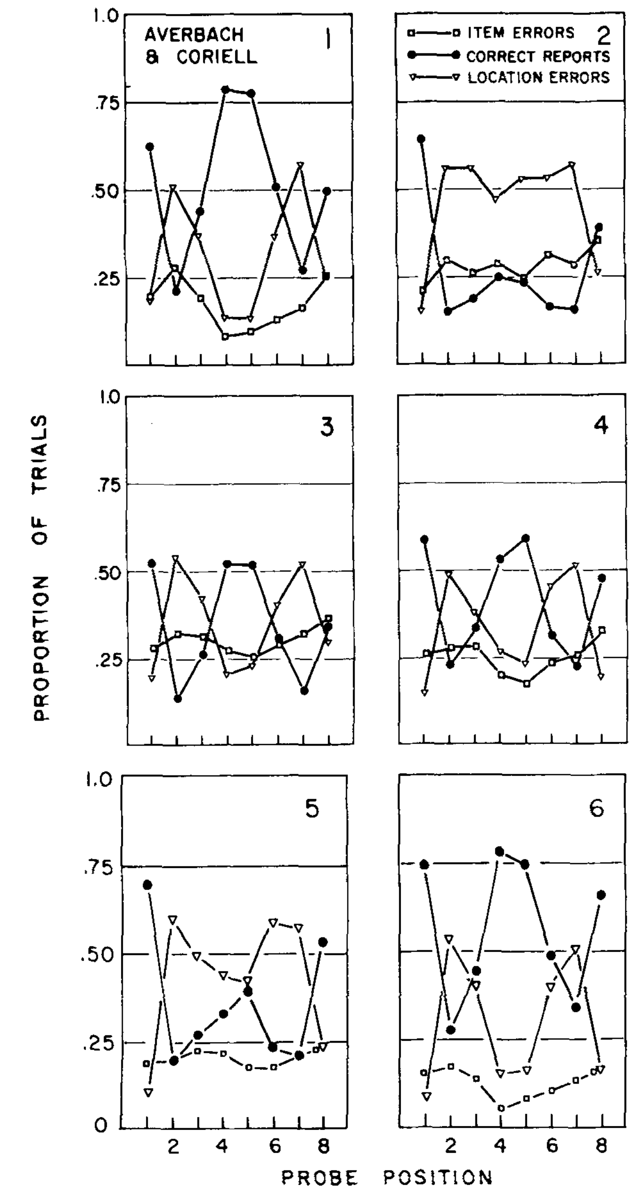

Figure 3. Accuracy of report, location errors, and item errors as a function of probe position and display condition.

That localization is the major limitation to performance is, of course, consistent with the dual buffer account. Location errors reflect addressing difficulty at the character buffer. Thus, relatively few location errors occur at the natural spatial anchors, the ends and the fixation point, and, as is shown in the appendix, the bulk of the errors were adjacent to the letter probed.

Finally, within the dual buffer account, the small increase in item errors associated with increased delay of the probe could reflect one of two possibilities. On the one hand, the decrease in performance may reflect decay of information in the feature buffer. If so, the small advantage for an immediate cue would reflect a selective process at the feature-buffer level. On the other hand, the decrease may reflect a slow decay of identity information in the character buffer. For reasons elaborated later, we prefer the latter view.

Masked Conditions

Two methods were used to control the SOA of the target to the mask (i.e., the processing time). In Condition 3, the SOA was varied by extending the target's duration with a zero interval separating the target and the mask (cf. Merikle & Glick, 1976). In the remaining conditions, the SOA was varied by delaying the mask various intervals after a fixed-duration target.

As is shown in Figure 3, all conditions showed a complementary pattern between correct reports and location errors when plotted across the stimulus array. Thus, correct reports took a W shape and the corresponding location errors took an M shape. As in the no-mask condition, the quartic trends were highly significant for both dependent measures [$F(1,13) = 182.48$, 122.82, 114.36, $F(1,7) = 94.95$, $F(1,17) = 267.14$, for correct reports in Conditions 2-6, respectively, all $ps < .001$; $F(1,13) = 68.31$, 192.74, 85.68, $F(1,7) = 114.29$, $F(1,17) = 215.47$, for location errors in Conditions 2-6, respectively, all $ps < .001$]. For Condition 2, the only masked condition in which the probe and target had an ISI greater than zero, the quadratic trend was also significant for both dependent measures [$F(1,13) = 35.13$, for correct reports, and $F(1,13) = 66.38$, for location errors]. The complementary pattern illustrates the role of localization processes in determining performance and replicates the data reported by Mewhort and Campbell (1978; Campbell & Mewhort, 1980, Experiment 1).

As shown in Figure 2, increasing the SOA increased accuracy of report in all cases [$F(4,52) = 11.96$, 43.95, 47.94, $F(4,28) = 8.40$, and $F(4,68) = 48.52$, for Conditions 2-6, respectively, all $ps < .001$]. Although accuracy of report increased as SOA increased, the pattern of errors depended on the range of SOAs. Conditions 2-5 involved relatively short SOAs, but Condition 6 involved relatively long SOAs.

For the short-SOA cases (Conditions 2-5), the increase in accuracy across SOA was complemented by a decrease in item errors. Conversely, for the long-SOA case (Condition 6), the increase in accuracy was complemented by a decrease in location errors; item errors, however, decreased modestly. For item errors, the effect of SOA was significant in each group [$F(4,52) = 29.68$, 43.46, 52.18, $F(4,28) = 13.87$, F(4,68) = 7.03, for Conditions 2-6, respectively, all ps < .001]. For location errors, however, the effect of SOA was significant in Condition 6 only [F(4,68) = 20.97, p < .001].

In summary, the mask had two qualitatively different consequences, depending on the range of SOA. For the low-SOA range (Conditions 2-5), increasing SOA decreased item errors but left location errors at about the same level. For the high-SOA range (Condition 6), increasing SOA decreased location errors dramatically but had only a modest effect on the number of item errors.

In general terms, the decrease in item errors associated with increased SOA reflects the action of the mask at the feature buffer, and the remaining errors reflect localization difficulties at the character buffer. While true in general terms, the division of errors to the two buffers is not exact: A misidentification due to inaccuracy at the feature buffer can be scored as a location error. Similarly, a report of a misidentified letter adjacent to the item probed is likely to be scored as an item error; that is, location errors cannot appear unless identification is relatively good (see Footnote 2).

Figure 4 shows correct reports and location errors for both Condition 1 (the no-mask case) and Condition 2 (the corresponding mask case). As is clear in the figure, the mask reduced accuracy of report at the middle of the array more than at the ends (illustrating the selective masking effect discussed by

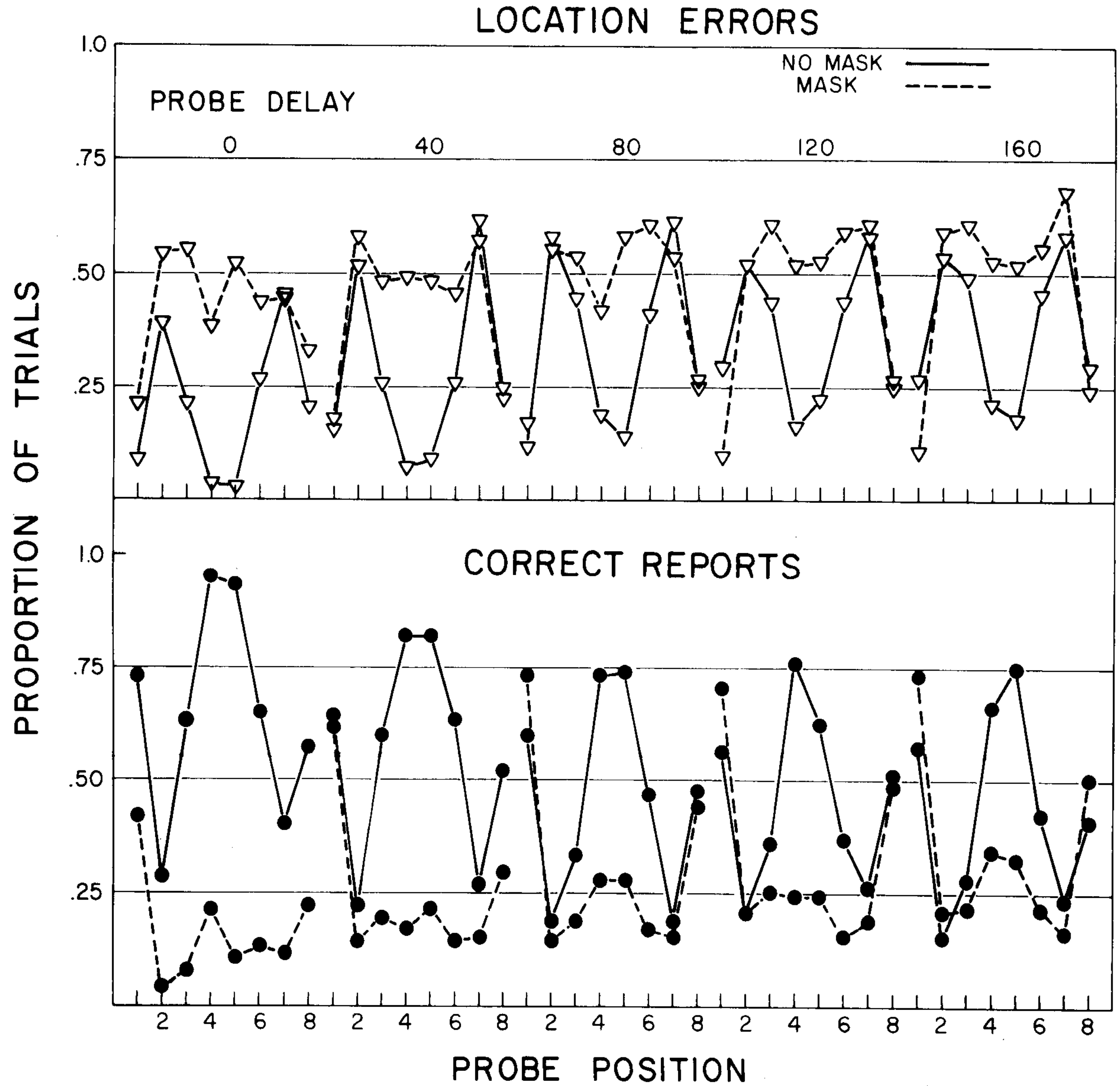

Figure 4. Accuracy of report and location errors as a function of probe position, probe delay, and masking. The no-mask and mask conditions are Conditions 1 and 2, respectively.

Mewhort & Campbell, 1978). Consistent with the earlier results, the reduction in accuracy of report was balanced by a corresponding increase in location errors; that is, the mask reduced accuracy from the middle positions by increasing localization errors.

Increasing the SOA of the target and mask did not increase the number of location errors until the SOA was relatively long (see Figure 2). Nevertheless, as is clear in Figure 4, even at a relatively short SOA, the mask introduced location errors in the middle of the display; that is, it had a marked effect on spatial information at the character buffer.

The null effect of increased SOA on the total number of location errors may appear to conflict with the clear effect of masking on location errors across the stimulus array. The conflict reflects the problem of measurement. It is tempting to think that all item errors reflect identification problems and that all location errors reflect localization difficulties. The division of errors into item and location classes, however, does not map directly onto their corresponding causes. Because item and location errors do not map directly onto identification and localization processes, one should not expect an effect on the overall number of location errors at short SOAs: Although one can see the effects of masking when looking across probe positions, the number of location errors cannot increase until identification has achieved a satisfactory level.

In summary, at short SOAs (e.g., less than about 150 msec), both identification and localization failures occur. In terms of the dual buffer model, the mask affects both buffers. But, if the mask has caused several misidentifications, a failure of localization may be hidden. For long SOAs (e.g., greater than about 150 msec), however, the mask has little effect on the identification processes associated with the feature buffer but can still distort spatial information in the character buffer and, consequently, can produce location errors.

According to the traditional account, delaying the probe reduces accuracy by permitting features in the register to decay. If a mask disrupts the feature information, an assumption consistent with the tradeoff of correct reports with item errors across the SOAs, combining a mask with the delay-of-probe manipulation should accelerate the loss of features. When combined with a mask, then, even an immediate probe should find feature information reduced to the level associated with a long delay in a no-mask case. Thus, there should be a much less pronounced effect of delaying the probe when the manipulation is accompanied by a mask. Further, as both masking and delaying the probe are thought to affect basic feature information, the reduction in performance should be matched by an increase in item errors.

Condition 2 involved a delayed probe confounded with a delayed mask. Condition 4 involved an immediate probe combined with a delayed mask. By subtracting performance on Condition 2 from that on Condition 4, we can estimate the delay-of-probe effect when a mask is present. Condition 1, of course, involved the delay-of-probe manipulation without a mask.

Figure 5 is a re-plot of the accuracy-of-report data for Conditions 1, 2, and 4. In addition, it includes the error data for Conditions 2 and 4.

As is clear in Figure 5 (bottom left panel), delaying the probe reduced accuracy of report; that is, accuracy of report in Condition 4 exceeded that in Condition 2 (the shaded area) [$F(1,52) = 10.86$, $p < .01$]. Further, the difference between the two conditions increased linearly as the probe was delayed, yielding a significant interaction [$F(1,208) = 14.88$, $p < .001$].

The reduction in accuracy of report was accompanied by a corresponding increase in location errors (Figure 5, bottom right panel). Delaying the probe increased location errors; that is, the number of such errors in Condition 2 exceeded that in Condition 4 (the shaded area) [$F(1,52) = 11.67$, $p < .01$]. Further, the difference in location errors increased linearly as the probe was delayed [$F(1,208) = 7.29$, $p < .01$].

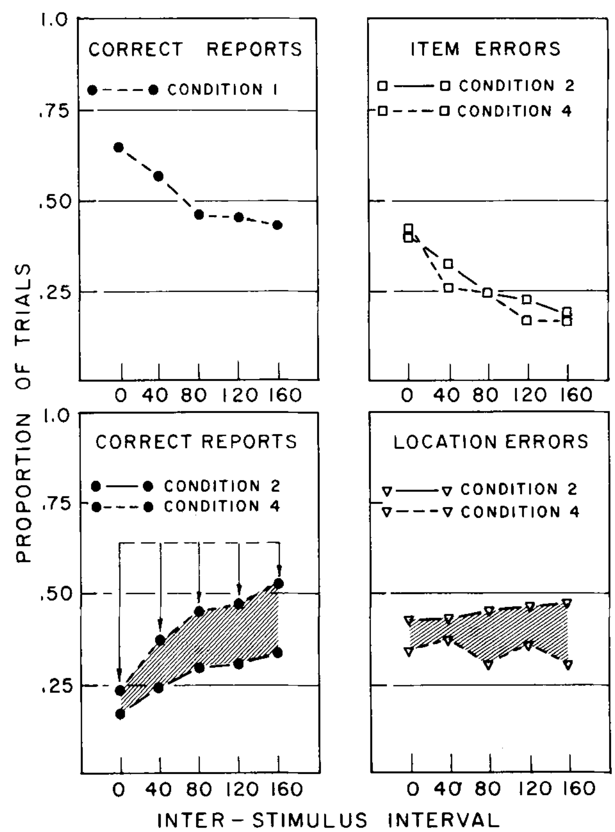

Figure 5. Accuracy of report in Conditions 1, 2, and 4 (left panels) and errors in Conditions 2 and 4 (right panels). The data are reproduced from Figure 2.

Finally, delaying the probe did not affect item errors. The comparison is shown in the top right panel of Figure 5, and neither the overall difference between Conditions 2 and 4 nor the corresponding interaction of that comparison with ISI was significant [$F(1,52) = .65$ and $F(1,208) = 1.16$, respectively]. Thus, contrary to the predictions derived from the traditional account, the effect of delaying the probe when the mask was present was similar to that when the mask was not present.

The effect of delaying the mask, independent of the probe, is shown in the bottom left panel of Figure 5. The horizontal line represents the level of accuracy associated with zero ISI in Condition 1, and the arrows illustrate the effect of delaying the mask with an immediate probe (i.e., the difference between Conditions 1 and 4).[5]

The comparisons illustrated in Figure 5 are interesting in another light: The dual buffer account suggests that subjects use the probe to address letters at the character buffer. Alternatively, it might be argued that subjects use the probe to address material at the feature level. For all but the shortest SOA in Condition 4, the probe preceded the mask, whereas the two events were concurrent in Condition 2. Thus, relative to the situation in Condition 2, the potential exists for subjects in Condition 4 to exploit the earlier cue by attending selectively to the features indicated by the probe. Under the selective attention hypothesis, one would expect the increase in accuracy of report shown in the bottom left panel of Figure 5. However, assuming selective attention benefits identification processes, the selective attention idea also predicts a corresponding difference in item errors, not in location errors. Thus, the pattern of errors offers no support for an account postulating selective analysis of the feature array (see Butler, 1980, for another example); that is, identification precedes addressing with the probe.

Conditions 4 and 5 compare the duration of the probe. As is clear in Figure 2, accuracy of report increased less rapidly with a long-duration probe (Condition 5) than with a short-duration probe (Condition 4). Further, at all delays of the mask, relative to the short-probe condition (Condition 4), the long-probe condition (Condition 5) produced more location errors. The latter result may seem to be paradoxical: Many believe that a short-duration probe should be more uncertain than a long one and, as a consequence, should yield less accurate performance. Nevertheless, the long-duration probe reduced accuracy by increasing location errors, a pattern that replicates data reported by Townsend (1973) using a no-mask situation.

Figure 6 presents a summary of the data. The three panels show correct reports, item errors, and location errors plotted as a function of the SOA of the target and the mask (processing time). The no-mask cases (i.e., Condition 1 and one cell from Condition 6) are labeled as an infinite SOA.

As is clear in Figure 6, increasing the SOA increased accuracy and reduced errors, in particular the item errors. Relating item errors to SOA, the function $y = 5.188x^{-.535}$ accounts for about 78% of the variance. While the item errors can be described in terms of a simple function, the correct reports and location errors cannot. Correct reports did increase across SOA, but the increase was disorderly. Similarly, the

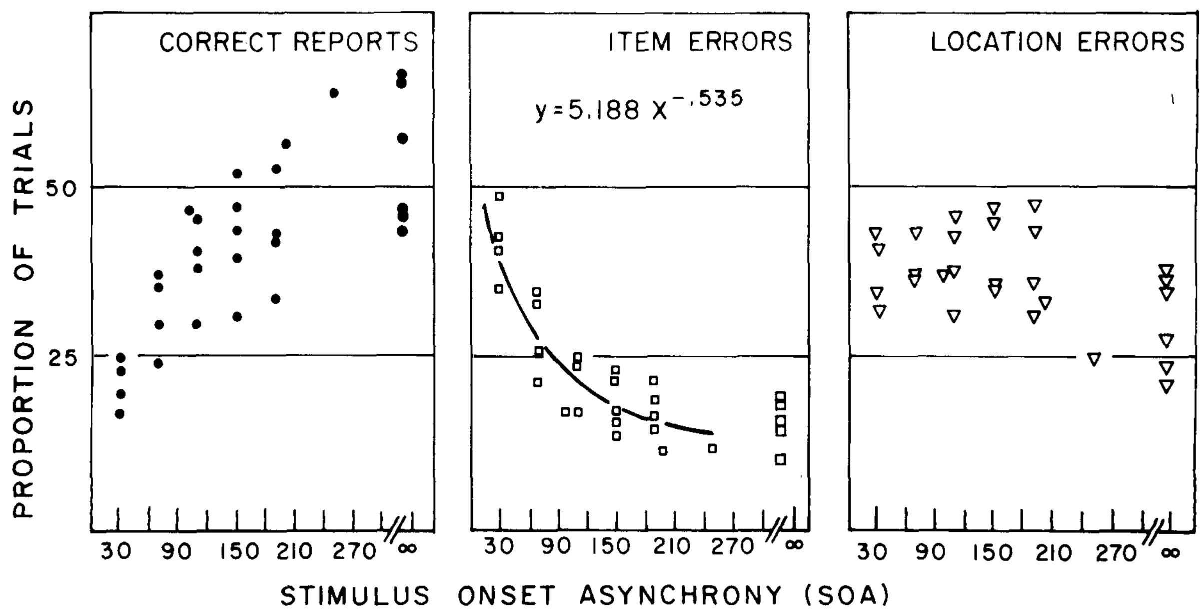

Figure 6. Accuracy of report, item errors, and location errors as a function of the SOA of the target and the mask. The no-mask cases are represented at an infinite SOA, and the figure includes data from all six conditions.

location errors did decrease across SOA, but the decrease was small and disorderly. Finally, the mask affected both item and location errors, but its time course was different: The mask had an effect on location errors at SOAs too long to affect item errors.

The pattern presented in Figure 6 is exactly what one would expect from the dual buffer account: SOA controls both the mask's effect on information stored in the feature buffer and the mask's effect on spatial clarity at the character buffer. Because identification precedes use of the probe at the character buffer, item errors (clear failures of identification) must carry through the remaining processing. Looking across the SOA conditions, because location errors include postidentification sources of spatial uncertainty—sources associated with the delayed probe and with the mask's effect at the character buffer—both correct reports and location errors must be somewhat more noisy than item errors, a measure that reflects the initial and more straightforward SOA-feature relation.

The Familiarity Effect

In both the mask and the no-mask conditions, subjects were shown pseudowords of four orders of approximation to English. Figure 7 shows the correct reports and the item errors as a function of approximation to English. In all cases, accuracy of report increased with increased order of approximation to English [$F(3,39) = 59.34$, 12.63, 8.02, 12.67, $F(3,21) = 16.28$, and $F(3,51) = 47.40$, for Conditions 1-6, respectively, all $ps < .001$]. Similarly, item errors decreased in all cases with increased order of approximation to English [$F(3,39) = 48.60$, 16.54, 26.19, 6.13, $F(3,21) = 12.27$, and $F(3,51) = 16.02$, for Conditions 1-6, respectively, all $ps < .002$]. As is clear in Figure 7, moreover, the increase in correct reports matched the decrease in item errors across the four orders of approximation, replicating the pattern reported both by Campbell and Mewhort (1980, Figure 3) and by Mewhort and Campbell (1978, Figure 3). The proportion of location errors can be calculated by subtracting the sum of the correct reports and the item errors from one; thus, the tradeoff between correct reports and item errors indicates that the kind of material did not affect the frequency of location errors.

As Campbell and Mewhort (1980) indicate, the null effect of approximation to English on location errors combined with the tradeoff of correct reports with location errors across the stimulus array (Figure 3) limits the kind of mechanism one can postulate to explain the familiarity effect. In particular, it limits the way one can combine shape and letter frequency information during letter identification.

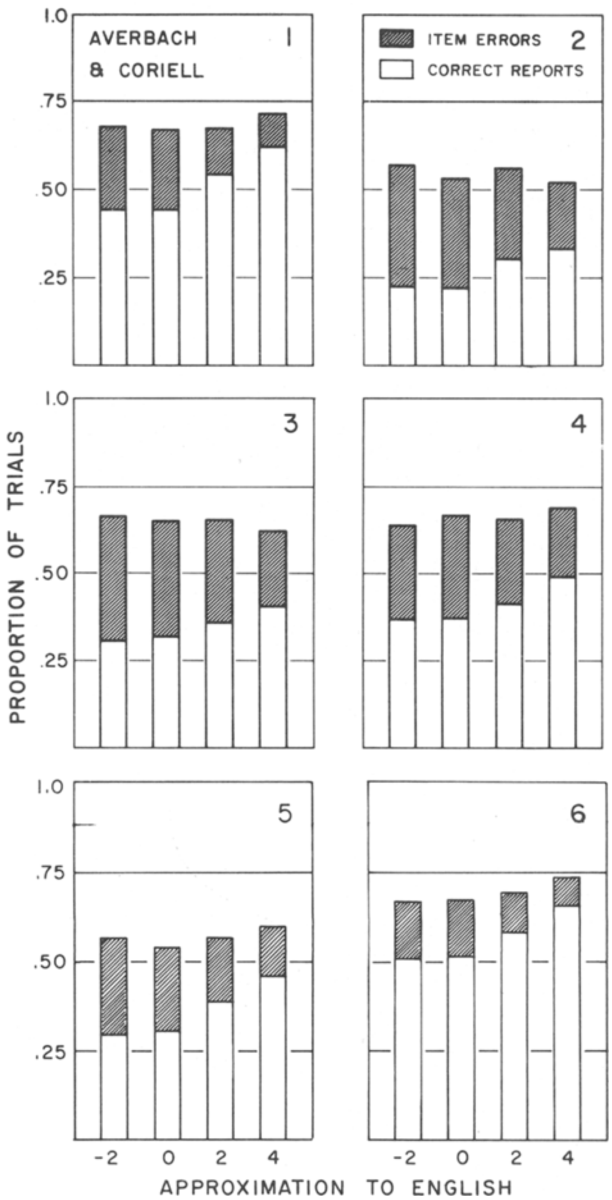

Figure 7. Accuracy of report and item errors as a function of approximation to English and display condition.

The dual buffer account holds that the letter recognition mechanism uses letter frequency information as part of the analysis of shape (i.e., feature) information, specifically as part of an error-correction algorithm. Thus, the dual buffer account provides an intimate link associating use of shape and letter frequency information.

Alternatively, one could postulate an account that separates the use of frequency information from the feature analysis process. There is ample precedent for such an idea. Rumelhart (1970, Postulate 5, p. 193), for example, has suggested exactly that position.

Massaro and Klitzke (1979) have also suggested a model that requires an extreme split between use of shape and frequency information. In basic form, the idea is that subjects report what they can identify and guess material they cannot identify. Presumably, subjects used an educated-guessing strategy; that is, they supply responses to unidentified items by guessing according to letter frequency information.

Both the dual buffer account and an educated-guessing account predict an increase in correct reports and a rough tradeoff with item errors. In contrast to the dual buffer account, however, the guessing view fails because it predicts increased location errors for the higher order material. Similarly, the guessing view has difficulty explaining the consistent tradeoff of correct reports with location errors, typically adjacent location errors, across the stimulus array.

While considering the use of letter frequency information, recall that the bar-probe task is thought to involve a low-level application of orthographic knowledge. As Campbell and Mewhort (1980) document, other tasks use more sophisticated orthographic knowledge; the bar-probe task illustrates only the "front end" of a larger mechanism.

CONCLUDING COMMENTS

The present experiments have contrasted two accounts of performance in the bar-probe task. The first view is the familiar "iconic memory" account. According to that account, the decrease in performance associated with a delayed probe reflects decay from a precategorical sensory register, a loss of feature information similar to a fading picture. The second, a dual buffer information processing account, suggests that the decreased performance reflects difficulties in localization rather than a loss of feature information.

While the iconic memory account can explain the decreased performance associated with a delayed probe, it is not consistent with (1) the nature of the errors with a delayed probe, (2) the effects of a mask on errors with a delayed probe, (3) the effects of a mask on errors across the stimulus array, (4) the effect of a delayed probe when combined with a mask, and (5) the interrelated pattern of errors and correct reports across various orders of approximation to English. The dual buffer account, in contrast, is consistent with each of the foregoing.

The data point clearly to a major role for localization processes and, simultaneously, deny the traditional metaphor of a fading image. To a large extent, the success of the dual buffer account, particularly its treatment of the errors associated with a delayed probe, lies in its stress on localization factors. The emphasis on localization, of course, parallels the separation of identification and addressing mechanisms implied by the two buffers.

Recently, Treisman and Gelade (1980) have advanced an attentional model of feature analysis. At a global level, their account contrasts with the dual buffer view because it seems to suggest that one must locate items before they can be identified, whereas we assign character localization to a buffer that holds identified items.

The contradiction implied by the contrast is more apparent than real. Treisman and Gelade (1980) refer explicitly to feature analysis. As we indicated earlier, spatial errors at the feature level should yield item, not location, errors, and we acknowledge that an early feature-bundling or figure-ground computation is part of the feature analysis. Spatial factors at the feature level, however, should not be confused with shifts of whole characters (i.e., with location errors produced by confusion at the character buffer). While not relevant to location errors, as the apparent contradiction suggests, the feature integration processes described by Treisman and Gelade are relevant to item errors. In particular, such processes may provide the basis for an account of item errors introduced by feature-level spatial confusion during masking.

Acknowledging a major role for localization processes, one might postulate an alternate account based on the single-buffer idea. Suppose subjects use the probe to address a feature bundle and then identify the letter indicated by the probe. In such an account, location errors would reflect an incorrect search through the feature buffer, and item errors would reflect loss of feature information. By tuning the relative difficulty of localization and identification processes, such an account might be able to handle the bulk of the present data, and because it requires only one buffer, the single-buffer idea may be preferred on grounds of parsimony.

While a single-buffer account may appear attractive, it includes a number of difficulties. We shall list three:

(1) If subjects use the probe to address the data at a feature level, it is hard to explain the high frequency of location errors. Presumably, features represent the visual display in "real" space (i.e., interfeature intervals are represented veridically). Given a precategorical feature representation, what could one expect if subjects misaddress the buffer (i.e., if subjects miss their aim when using the probe to direct attention)? Presumably, a near miss would pick up some of the correct features; but a miss is unlikely to err by discrete character units (as is required for location errors). Instead, a near miss is likely to pick up features from adjacent letters (i.e., to yield an inappropriate feature bundle) and, as a consequence, to yield item errors.

One might patch the difficulty for a single-buffer account by providing an explicit feature-bundling process prior to addressing with the probe. In effect, the addition would change the feature space from a continuous to a discrete representation. Like the guitar vs. the violin, such a mechanism adds frets to the feature space. With such a process in place, one could explain the preponderance of location errors. But, by adding to the "simple" single-buffer idea, it loses its claim to parsimony.

(2) If subjects use the probe to address the data at a feature level, one would expect the selectivity to benefit the identification process. Yet, the comparison of Conditions 2 and 4 (probe and mask concurrent vs. probe preceding the mask) showed that the benefit of the preceding probe was to localization, not to identification (Figure 5).

(3) If subjects use the probe to address the data at a feature level, it is not clear how one can explain the null effect of approximation to English on location errors. The difficulty is, of course, that a simple single-buffer account is likely to collapse into an educated-guessing account, the position that subjects fill in unidentified items by guessing according to letter frequency information. As we noted earlier, however, the data deny the educated-guessing view. While a more elaborate version of a single-buffer view could be constructed to avoid the difficulties of an educated-guessing position, the resulting account loses its claim to parsimony.

The comparison of Conditions 2 and 4 (Figure 5) provides clear evidence that selection occurs at a postidentification level, that is, that selective identification, in the sense of privileged use of particular feature data, does not occur. Francolini and Egeth (1980), however, have argued strongly that selective identification does occur. How can one resolve the conflict?

The two claims conflict only if we ask the global question "Does selective identification occur?" and expect a yes-or-no answer. By expecting a yes-or-no answer, however, we beg a more important question: "What parts of the system does a particular task illuminate?" Francolini and Egeth (1980) used a search-like reaction time task. Such a task is unlikely to tap the system at the character buffer (Campbell, 1979). If, as the present data suggest, the bar probe is used at the character-buffer level, there is no conflict: The tasks underlying the discordant claims tap the system at different points. Perhaps, as Newell (1973) argues, some questions may be too global.

Throughout the discussion of localization, we have implied that location errors reflect spatial clarity in the character buffer, that is, that they reflect the data in the buffer. One might argue, alternatively, that location errors reflect a mismatch between the probe and the array as a whole and, thereby, that they reflect an alignment difficulty, not a failure of the data within the buffer.

The present data do not permit an unambiguous decision on the issue, and the possibilities are not mutually exclusive (see Townsend, 1973, for a discussion of the issue). Nevertheless, we have interpreted the result in terms of the clarity idea rather than the misalignment idea to provide a unified account of some consequences of masking. In the bar-probe case, introducing a mask disrupts spatial clarity with clear consequences for localization (e.g., Figure 4). In a free recall task, subjects use spatial information in the character buffer to organize the character string for subsequent rehearsal in short-term memory (Mewhort, 1974; Mewhort & Campbell, 1980). Thus, disruption should appear as disorganization in the sequential report (Campbell, 1979, pp. 59-66). By appealing to the spatial clarity view, then, we can explain both consequences of masking with the same mechanism.

In real-time systems, buffers absorb time-of-arrival differences reflecting processes prior to the buffer. Consequently, it is difficult to assess timing characteristics of the buffers in the dual buffer account. Nevertheless, we have identified the character buffer with the abstract representation studied by Rayner et al. (1980). As they note, the duration of the representation is linked to eye movements. By associating the character buffer with Rayner et al.'s work, we mean to suggest that the duration of the character buffer is variable; it is determined by eye movements (see Just & Carpenter, 1980, for speculations concerning the determinants of eye movements).

A final point deserves mention. In his recent review of the iconic memory literature, Coltheart (1980) has distinguished visible persistence, informational persistence, and neural persistence. He argues that each kind of persistence has its own empirical support, that the three are often muddled in general discussions of iconic memory, and that the relation among the three represents an unsolved empirical question.

Coltheart's (1980) distinction between visible and informational persistence echoes an earlier report by Davidson, Fox, and Dick (1973). They presented a five-letter display followed by a one-character mask. The mask was presented shortly after a voluntary eye movement that shifted the subject's fixation laterally two character positions. The perceived location of the mask did not match the location of its informational effect: The mask blanked report of one letter but appeared to be positioned over a different letter. The position of the informational disruption occurred in retinal space; that is, the letter blanked was the item aligned with the mask on the retina after the eye movement. The perceived location of the mask occurred in "real" space; that is, the location compensated for the movement of the eyes. Clearly, the informational persistence, indicated by the mask's power to disrupt report, differed from visible persistence, indicated by the mask's perceived location. In terms of the dual buffer model, we assume that the informational disruption reflects the mask's effect at the feature buffer and that the mask's location involves the character buffer. Our interpretation is speculative, but it illustrates the most important implication of the dual buffer model. Iconic memory is a passive construct that oversimplifies the information processing required in the barprobe task.

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NOTES

1. Following Dick (1969), Di Lollo (1977) tried to separate spatial vs. identity information by comparing free recall performance to that in a modified probe task. Free recall tasks do not require subjects to preserve spatial information explicitly, whereas probe tasks obviously do require such information. Di Lollo assumed that if subjects were not required to preserve the information, they would not use it. In his words, "in full report . . . the retention of spatial information has no bearing on performance" (Di Lollo, 1977, p. 41). Consequently, he reasoned that a comparison of the two tasks would expose spatial processing. The force of the argument, however, depends on the assumption that subjects

do not use spatial information in the free recall task: While subjects are not required to preserve spatial information in free recall, the fact that they invariably report from left to right suggests that they use spatial information to organize the report sequence (see Bryden, 1967; Mewhort, 1974). Indeed, it is difficult to imagine how subjects manage any degree of uniformity in report order unless they use such information as an organizational aid.

Aside from the somewhat questionable comparison with free recall, Di Lollo (1977) used a ring circling one letter as both a probe and a mask. Thus, he was not able to separate the delay-of-probe effect from the delay-of-mask effect. In terms of the present work, his experiment resembles Condition 2, which also confounds the probe and the mask. Unfortunately, Di Lollo did not include conditions similar to Conditions 1 and 4 and, consequently, was unable to separate the confounded effects.

2. Terminology for the errors is problematic; if a subject reports a letter not shown on the trial, we classify the response as an item error, and such errors represent bona fide examples of misidentification. If a subject reports an item shown on the trial other than the letter probed, however, we classify the response as a location error. While the classification of errors is straightforward, their cause is not. A location error can arise because of a failure of localization or because of a failure of identification. We need, in fact, two sets of terms, one set to describe the error and another to describe its cause.

3. In fact, Townsend (1973) reported that correct reports declined across probe delays, whereas item errors were constant. We have inferred the increase in location errors (by subtraction).

4. Increasing SOA by increasing target duration (with a zero ISI to the mask), we permit temporal summation on the CRT, and, as a result, SOA is confounded with intensity. We have included Condition 3 to replicate Merikle and Glick (1976); they did not mention the confound, nor did they offer an appropriate countermeasure.

5. When considering the loss of accuracy with a delayed probe in Condition 1 vs. the difference between Conditions 2 and 4 (the comparisons illustrated in the left panels of Figure 5), it is tempting to ask whether or not the changes are of the same size. Half of the comparison involves a difference manipulated between subjects (i.e., the difference between Conditions 2 and 4). The other half of the comparison involves a within-subjects manipulation (i.e., the delay-of-probe manipulation in Condition 1). We know of no standard statistical technique that permits us to contrast the same manipulation conducted both between and within subjects.

APPENDIX

The following tables present a summary of the data for each condition, approximation to English, and ISI/SOA. The summary takes the form of 120 8 by 8 confusion matrices. Five matrices are provided for each condition at each approximation to English: The five matrices summarize each ISI/SOA, with the shortest presented at the left. Columns in the matrices represent Probe Positions 1-8, reading from left to right. Rows represent the position in the pseudoword from which the report has been taken. Thus, the diagonals (reading from top left to bottom right of each matrix) represent the number of letters reported correctly. The off-diagonal entries indicate the frequency and position of the location errors. Item errors can be calculated at each probe position from the column maximum. The column maximum is twice the number of subjects in each condition (i.e., 2 times 14 for Conditions 1-4, 2 times 8 for Condition 5, and 2 times 18 for Condition 6).

CONDITION 1

-2-ORDER APPROXIMATION TO ENGLISH

15	5	2	0	0	0	0	0
0	7	1	0	0	0	1	0
2	4	18	1	0	2	0	0
0	0	2	26	2	1	0	0
0	1	0	0	22	4	1	0
0	0	0	0	1	17	6	2
0	0	0	0	0	2	10	3
2	1	0	1	0	1	4	11

17	5	1	1	0	0	0	0
1	6	0	0	0	0	0	0
3	2	19	1	0	0	1	1
0	3	2	20	2	0	1	0
1	2	0	0	22	6	3	0
1	1	0	0	0	16	12	4
0	0	0	1	1	1	2	2
0	1	0	0	0	2	5	13

14	12	1	1	0	0	1	0
1	0	1	0	0	1	0	0
1	2	7	1	0	0	2	0
0	4	7	16	1	0	2	0
1	0	2	3	21	8	2	1
0	0	0	0	0	11	3	7
0	0	0	1	0	2	4	1
0	1	0	0	0	1	6	10

16	6	1	1	0	0	0	0
0	1	1	0	0	0	0	0
0	4	6	2	1	0	0	0
1	0	7	18	2	1	1	1
2	3	1	1	16	8	6	4
0	0	1	2	1	7	7	1
1	0	0	0	0	3	2	2
0	1	1	1	0	2	6	14

16	5	1	2	0	0	0	0
1	1	1	0	0	0	0	0
0	7	6	1	1	0	1	1
1	1	8	19	0	3	0	0
3	2	1	1	22	6	2	0
1	2	0	0	1	10	5	5
0	0	0	1	0	4	6	1
2	1	1	0	1	2	4	12

0-ORDER APPROXIMATION TO ENGLISH

24	2	1	0	0	1	2	0
0	6	1	0	0	0	1	0
1	6	15	0	0	0	1	0
1	1	1	26	0	3	0	0
0	1	2	0	28	5	3	1
0	1	1	1	0	15	6	3
1	0	0	0	0	1	8	2
0	0	0	0	0	0	0	13

14	10	0	0	0	0	0	0
2	3	3	0	0	0	1	1
0	5	11	1	0	0	1	3
0	3	4	25	1	0	1	0
1	1	4	1	24	2	0	0
0	0	0	0	0	22	4	3
1	0	1	0	0	0	10	3
0	0	1	0	0	0	8	9

13	8	5	1	2	0	1	0
0	2	0	1	0	0	0	3
1	6	8	2	1	0	0	2
2	1	6	19	0	0	0	0
2	0	1	0	19	9	4	0
0	0	0	1	1	11	4	2
0	2	0	2	0	3	7	0
0	1	0	0	0	0	4	7

12	6	3	0	2	0	0	1
5	1	2	0	0	0	1	1
1	6	7	2	1	0	0	2
2	2	7	22	6	0	0	0
1	4	0	2	9	9	5	1
1	0	1	0	2	9	5	0
0	0	1	0	1	1	6	0
0	0	0	0	0	0	2	11

18	6	0	1	1	1	0	1
0	2	2	2	0	0	1	4
2	3	6	2	0	0	0	0
1	2	8	15	2	0	0	0
0	3	3	0	21	7	6	1
0	0	1	2	0	10	13	3
0	0	1	1	1	3	2	2
2	0	0	1	0	0	0	6

2-ORDER APPROXIMATION TO ENGLISH

22	5	0	0	0	0	0	0
0	7	1	0	0	0	0	2
0	4	17	0	0	0	0	0
1	0	5	27	0	0	0	0
0	1	1	1	28	7	1	1
0	0	0	0	0	19	7	3
2	1	0	0	0	0	15	2
0	0	0	0	0	0	3	18

21	4	0	0	0	0	0	0
1	7	5	0	0	1	0	1
1	5	17	2	0	0	2	0
0	0	1	22	2	0	0	0
0	1	0	0	24	8	1	1
0	0	0	0	0	15	9	0
0	1	0	0	0	0	8	0
1	2	1	0	1	0	3	20

20	3	7	2	1	0	0	0
0	7	2	0	0	0	2	0
0	9	9	0	0	3	1	3
0	2	4	23	3	1	1	2
0	0	1	1	22	5	4	2
0	0	0	1	0	12	11	0
1	1	1	0	1	1	3	2
0	1	0	0	0	2	2	15

16	8	3	1	0	0	0	0
1	7	2	1	0	1	0	0
6	4	17	1	0	1	2	1
3	3	2	20	5	1	1	1
0	1	1	2	21	8	4	0
0	0	0	0	0	9	6	3
1	0	1	0	0	4	9	3
0	0	0	1	0	0	4	15

13	3	2	0	0	1	1	0
1	4	2	0	0	0	2	0
6	7	12	2	1	0	1	1
0	1	5	19	5	1	2	0
0	0	1	1	20	11	2	2
1	1	1	1	1	11	11	3
0	0	0	0	0	2	6	2
1	3	1	1	0	0	1	12

4-ORDER APPROXIMATION TO ENGLISH

21	3	1	0	0	0	0	0
0	12	1	0	0	0	0	0
0	5	21	0	0	0	1	1
0	1	2	28	0	0	1	1
0	1	0	0	27	3	3	0
0	0	1	0	0	22	8	1
0	0	1	0	0	0	12	1
0	1	0	0	0	0	2	22

20	6	3	0	0	0	2	0
1	9	2	0	0	0	0	1
1	4	20	0	0	0	1	0
0	0	1	25	3	0	2	0
0	1	0	1	22	5	1	1
0	0	0	0	0	18	9	0
1	0	0	0	0	2	10	7
1	1	0	0	0	2	2	16

20	4	2	1	0	0	0	0
2	12	5	2	0	1	0	0
1	7	13	1	1	0	0	0
0	0	3	24	3	0	0	1
0	0	1	0	21	8	2	1
0	1	0	0	0	18	11	1
1	0	0	0	0	1	7	2
0	0	1	0	1	0	6	21

19	3	3	0	0	0	0	0
3	14	6	0	1	0	2	0
2	6	10	0	0	0	1	1
2	1	3	25	3	0	0	0
0	0	2	1	24	8	1	3
1	0	0	0	0	16	9	0
0	0	0	0	0	2	12	3
0	0	0	0	0	0	2	17

17	6	4	1	0	0	2	0
4	10	0	2	0	0	0	0
2	4	7	1	0	0	0	0
1	0	8	21	4	2	0	0
1	2	2	0	21	5	3	1
0	1	1	0	2	16	6	1
0	0	1	0	0	2	12	5
0	0	0	1	0	1	2	15

CONDITION 2

-2-ORDER APPROXIMATION TO ENGLISH

11	7	7	3	5	4	3	3
0	0	1	1	2	1	2	1
0	2	2	0	2	2	2	2
4	0	0	4	0	2	2	0
0	3	1	2	5	2	1	1
0	0	3	1	2	4	1	0
0	1	1	0	1	0	4	2
0	0	0	0	1	0	0	5

13	9	3	3	3	1	3	0
4	4	1	0	0	1	0	1
0	1	4	3	1	0	1	0
0	0	1	4	1	2	2	4
2	0	1	3	7	2	2	0
1	1	2	3	3	4	1	2
0	0	1	0	0	7	4	0
1	2	1	1	3	1	3	8

18	8	3	1	3	2	2	1
1	2	2	0	4	2	1	0
0	1	5	5	2	1	1	2
1	4	4	2	4	2	0	1
1	2	1	1	4	6	2	0
1	0	0	2	2	3	5	1
0	0	2	3	1	1	1	2
1	0	0	2	2	1	4	13

18	7	4	3	3	0	0	0
2	1	1	2	0	1	3	0
1	2	5	0	1	1	1	0
0	2	6	9	5	4	3	1
1	1	0	5	4	5	5	1
1	0	2	1	0	3	2	6
0	1	2	0	2	1	5	2
0	0	0	1	2	2	4	10

16	0	3	2	1	0	0	1
1	2	2	2	2	1	0	0
0	5	5	6	4	0	2	1
0	8	6	10	6	2	4	0
0	2	3	1	8	9	7	3
2	0	2	0	2	7	3	2
0	2	3	0	0	1	6	2
0	0	0	3	1	0	3	11

0-ORDER APPROXIMATION TO ENGLISH

15	9	2	5	2	3	2	2
0	0	3	0	2	0	0	2
0	1	1	2	3	0	2	2
0	1	5	5	1	2	1	0
2	1	2	2	1	4	7	1
1	0	1	0	3	3	3	1
0	0	2	0	3	2	3	5
1	3	1	0	2	1	0	1

18	13	8	1	4	3	1	0
3	2	2	3	1	1	1	1
0	0	4	2	1	0	0	1
1	2	1	5	4	0	3	0
0	2	2	4	3	2	0	2
0	1	2	0	2	4	4	1
0	0	0	1	2	1	5	3
0	0	0	1	1	2	4	5

16	9	4	3	2	1	3	1
2	2	2	2	2	0	2	3
0	3	7	6	3	1	1	0
6	1	6	7	4	1	3	0
0	2	1	0	10	8	2	0
1	0	0	0	3	5	2	0
0	2	1	0	0	6	2	6
0	0	0	0	0	1	0	6

21	7	6	1	2	0	4	1
0	4	2	2	2	1	3	0
0	2	4	1	0	2	0	0
1	4	8	7	3	3	4	0
2	0	2	3	7	4	1	2
1	1	2	2	2	3	3	2
0	1	0	3	2	1	4	2
0	0	2	1	3	2	1	7

19	4	5	2	4	6	0	2
2	5	5	4	1	0	2	1
0	6	2	1	3	5	1	0
1	6	6	10	3	2	2	1
1	1	1	4	8	4	4	1
1	1	1	0	2	1	7	2
0	0	0	2	1	2	4	2
1	0	1	0	0	1	3	11

2-ORDER APPROXIMATION TO ENGLISH

14	10	3	4	6	1	1	2
0	0	3	1	1	1	1	2
2	2	5	4	1	0	2	1
0	1	1	4	3	2	2	0
2	2	3	0	5	1	1	1
2	0	0	1	2	3	3	1
0	1	2	0	1	5	4	0
0	1	0	3	1	1	0	7

14	8	5	3	3	2	1	3
0	7	3	3	1	2	2	0
1	2	7	2	2	2	5	0
5	2	2	4	2	3	2	0
0	1	1	0	4	5	2	0
0	1	0	3	2	3	3	2
1	0	1	1	1	2	4	1
0	0	0	2	2	0	4	10

26	7	4	5	1	4	0	0
0	6	4	4	1	2	4	0
0	2	7	1	2	2	1	0
0	1	2	13	9	2	4	0
0	4	1	1	9	2	1	1
0	0	2	0	2	5	2	0
0	0	0	0	3	1	9	2
0	0	0	0	0	1	2	14

17	7	4	6	0	4	2	0
0	7	5	3	2	0	2	0
0	7	9	5	2	1	2	1
0	0	4	3	6	2	2	0
0	0	0	2	10	7	3	3
0	2	2	1	2	5	4	1
0	0	1	0	1	4	6	2
2	1	0	1	0	2	2	18

21	6	3	1	0	1	0	0
0	6	1	1	1	4	2	1
0	6	5	10	3	1	1	0
2	4	6	10	8	1	1	0
0	1	3	3	9	6	4	1
0	0	1	0	0	8	8	0
0	0	0	1	1	2	5	1
0	0	2	0	2	0	1	17

4-ORDER APPROXIMATION TO ENGLISH

7	6	12	5	4	5	1	3
4	5	1	1	0	1	3	1
1	1	1	1	4	1	0	0
1	2	4	11	1	1	1	2
1	2	1	4	1	2	2	2
0	0	0	0	5	5	5	0
2	4	2	0	1	3	2	0
1	1	1	3	0	2	2	12

24	13	8	4	1	1	0	0
0	3	1	3	2	1	0	1
0	3	7	4	0	0	0	1
0	2	4	6	5	3	2	0
0	0	2	1	10	4	5	0
1	0	1	3	5	5	10	2
0	1	0	1	0	3	4	0
0	1	1	0	2	0	3	10

22	10	11	1	1	1	1	2
2	6	3	3	3	4	1	0
0	3	2	3	1	1	0	0
0	2	3	9	6	1	3	2
0	1	2	0	8	9	1	0
1	0	2	3	2	6	6	2
1	0	0	1	1	2	5	2
1	0	0	0	1	3	6	16

23	6	4	2	3	0	1	1
0	11	5	2	1	2	0	1
0	4	10	8	4	1	3	0
0	1	5	8	7	5	2	0
0	0	1	2	6	6	2	2
0	0	0	0	3	6	8	1
0	1	0	0	0	2	6	1
0	1	0	1	1	3	1	19

26	9	1	3	3	0	0	0
0	10	4	1	0	1	2	0
0	4	12	8	4	2	2	1
0	1	5	8	5	1	5	0
1	0	3	2	11	8	3	0
0	0	0	1	1	8	6	2
0	0	0	1	0	1	3	3
0	0	1	0	0	1	3	17

CONDITION 3

-2-ORDER APPROXIMATION TO ENGLISH

10	7	5	1	0	0	2	2
0	1	0	0	0	1	0	0
1	1	3	4	0	1	1	1
2	1	5	6	3	0	2	0
1	0	1	0	6	3	1	2
2	0	1	2	2	6	2	1
3	0	0	0	0	2	2	0
1	0	0	0	0	1	3	3

15	6	4	2	1	1	1	1
3	2	2	0	0	1	1	0
1	3	2	1	0	0	2	0
1	1	4	9	4	4	2	2
0	2	1	0	10	5	1	0
1	2	1	2	1	8	3	0
1	0	0	0	1	1	1	4
1	1	0	0	0	0	4	8

14	5	4	0	0	2	1	0
0	2	2	1	1	3	1	1
0	5	9	2	0	0	0	0
0	3	3	17	3	2	0	4
1	0	1	1	14	2	2	3
0	4	2	1	1	9	4	1
0	0	0	0	1	3	6	2
1	0	0	0	0	1	2	11

14	6	6	1	0	0	2	1
3	6	0	1	0	1	2	0
1	4	10	0	0	0	1	0
1	0	4	17	5	2	2	1
1	1	1	1	16	7	4	2
1	0	1	0	1	9	2	1
0	1	0	0	1	2	1	3
0	1	0	2	0	0	3	15

14	1	4	0	0	2	2	2
0	4	1	0	0	0	0	1
3	7	11	2	2	0	1	0
1	5	1	20	1	1	2	0
0	1	2	0	16	3	2	1
0	0	1	0	1	8	3	3
0	0	2	0	2	2	2	4
0	0	0	0	1	2	3	5

0-ORDER APPROXIMATION TO ENGLISH

5	3	1	0	2	2	1	1
2	2	0	1	0	1	1	1
0	3	7	0	1	0	1	1
1	0	2	5	0	3	1	1
0	2	0	1	4	3	1	1
2	1	1	0	2	0	4	2
0	1	1	0	2	2	3	3
0	0	0	1	0	1	1	3

12	9	5	2	5	2	1	0
1	2	1	0	0	2	0	0
0	3	6	0	2	0	0	2
1	4	2	11	1	2	2	2
6	0	1	1	14	7	2	2
0	1	0	2	0	6	1	2
0	0	0	0	1	1	8	3
0	0	0	0	0	0	1	7

20	6	4	3	1	2	1	2
0	3	3	1	1	2	0	1
0	3	4	1	1	0	0	0
1	2	3	16	1	0	1	1
2	3	1	2	17	3	4	1
0	0	0	0	2	10	8	1
0	1	0	0	2	1	3	2
0	1	2	0	0	1	1	12

18	8	5	2	1	1	1	1
0	2	1	0	0	0	0	0
2	6	6	0	1	0	3	0
0	5	2	19	2	3	3	2
3	3	3	1	20	3	6	1
1	0	1	0	0	10	5	1
0	0	0	0	1	3	3	1
0	1	1	0	0	0	2	5

22	5	2	1	2	1	1	4
0	4	2	1	0	1	1	0
2	4	6	0	1	2	1	0
0	2	9	21	1	1	2	1
2	2	2	2	17	4	6	5
0	2	1	1	0	10	7	0
0	1	0	0	0	1	3	0
0	2	0	0	0	1	0	10

2-ORDER APPROXIMATION TO ENGLISH

10	5	4	1	0	0	2	0
3	1	1	0	2	0	0	0
2	2	2	2	0	0	1	1
0	4	1	11	5	1	0	2
0	2	1	0	13	5	0	0
1	2	0	0	0	8	5	2
1	2	1	0	0	1	2	1
0	0	0	0	1	0	2	8

14	12	6	2	0	0	1	0
1	1	3	0	1	1	0	2
0	2	7	2	2	2	0	1
2	3	2	9	1	0	1	0
0	0	2	1	16	5	5	1
1	0	0	0	2	8	3	2
2	1	1	0	0	1	2	1
0	1	0	1	1	1	6	4

14	9	4	1	4	0	3	2
1	1	2	0	0	2	3	2
2	2	7	1	0	0	0	1
1	4	4	17	2	3	1	0
1	0	3	2	17	5	4	1
0	1	1	0	1	10	2	1
0	0	0	1	1	1	6	2
0	0	1	0	1	0	1	11

15	3	3	1	1	1	1	0
1	6	1	1	1	0	2	2
0	3	14	1	0	1	1	0
1	4	3	19	2	3	1	1
0	1	3	2	17	4	0	1
1	1	0	1	0	11	7	2
1	0	0	1	0	2	10	1
2	1	1	1	2	0	3	9

14	1	3	0	0	2	1	1
0	7	5	0	1	0	0	0
0	5	8	3	1	1	0	1
1	4	3	20	0	3	2	0
1	3	2	2	21	2	4	0
0	3	0	0	0	12	11	1
0	1	0	0	0	2	4	2
0	1	1	0	0	0	2	15

4-ORDER APPROXIMATION TO ENGLISH

8	2	1	1	1	1	3	2
1	4	4	2	2	1	0	1
2	3	3	2	0	1	2	0
3	2	3	11	3	2	1	1
3	4	1	3	11	5	2	2
1	0	0	1	1	5	3	2
0	2	1	1	0	2	3	1
1	2	0	1	1	0	0	9

18	7	6	1	3	2	2	0
1	5	3	3	0	1	0	1
0	2	7	2	0	3	1	0
0	0	3	13	1	0	1	2
0	0	3	1	11	4	6	1
0	2	0	2	2	10	6	2
0	1	0	0	0	0	5	0
0	0	0	2	0	1	4	12

18	9	5	4	0	1	0	0
1	7	0	3	1	1	1	3
1	1	9	3	0	0	0	1
1	2	4	14	4	1	2	0
1	0	2	0	17	9	5	1
0	0	0	0	1	8	7	2
0	2	0	0	0	3	8	3
2	2	1	0	0	2	2	10

18	5	3	0	2	0	1	1
1	8	3	0	0	1	0	2
0	2	12	1	2	0	1	1
2	5	3	21	3	3	4	0
0	0	1	2	16	3	4	2
0	0	2	0	0	17	6	0
0	0	0	0	0	1	8	1
1	1	1	0	0	1	2	18

21	7	4	1	1	1	2	2
1	8	0	0	1	0	1	0
2	2	14	3	1	2	0	1
1	1	6	17	1	3	0	1
0	1	1	1	17	8	3	3
0	1	0	1	1	8	10	2
0	0	0	0	0	2	8	3
1	1	0	0	0	1	2	15

CONDITION 4

-2-ORDER APPROXIMATION TO ENGLISH

9	5	2	1	3	2	1	0
3	1	1	0	0	0	0	0
1	4	11	5	0	2	1	1
0	2	3	2	2	2	2	1
0	1	0	1	11	5	2	3
0	1	0	2	0	2	1	2
1	1	0	1	0	0	0	2
1	2	0	2	0	1	4	7

16	5	2	1	1	2	1	2
1	6	5	2	0	1	0	0
1	3	5	2	0	2	1	1
1	3	4	14	4	0	1	0
1	1	1	1	13	3	6	0
0	2	0	0	2	8	4	2
1	2	0	0	1	3	6	2
0	0	0	2	0	1	4	13

19	3	2	1	0	0	2	0
0	5	3	0	0	0	0	0
1	8	5	1	0	1	1	0
0	2	5	17	3	1	0	1
1	0	2	1	18	7	0	0
0	0	0	0	3	3	2	2
0	1	2	0	0	6	5	1
2	0	0	0	0	3	10	19

18	9	7	3	0	1	1	0
0	4	1	0	1	0	1	0
0	3	5	4	1	1	0	0
1	4	4	16	4	0	3	0
3	0	2	1	14	5	0	2
0	1	1	0	1	10	5	1
1	1	1	0	0	2	11	1
0	0	1	0	0	4	3	13

14	7	1	1	0	0	0	1
0	9	1	1	1	2	0	0
1	1	15	2	0	0	0	4
0	2	3	17	5	0	1	2
1	4	2	0	19	6	4	1
0	1	1	1	3	10	8	1
1	0	0	0	0	2	7	0
0	0	0	1	0	2	6	14

0-ORDER APPROXIMATION TO ENGLISH

16	5	2	3	0	2	1	1
0	1	1	1	1	0	0	0
1	3	5	2	0	2	0	3
2	2	2	10	5	0	0	0
1	1	1	1	9	5	3	2
0	1	1	0	1	2	5	1
0	1	0	0	1	2	0	1
0	1	0	2	1	3	1	2

12	8	8	2	1	0	0	1
2	6	5	2	2	0	0	0
2	3	7	0	0	2	3	0
1	1	0	12	3	1	1	1
0	2	2	2	14	6	2	1
0	1	1	1	2	2	6	0
1	0	0	0	0	5	3	0
2	0	0	0	0	1	4	8

17	5	3	2	0	2	0	2
0	3	2	1	0	1	1	2
1	3	11	0	0	0	0	0
1	3	2	18	0	0	1	0
0	0	1	0	25	6	1	0
1	1	0	0	0	9	3	0
0	0	0	0	0	3	8	3
0	1	0	0	1	0	5	14

17	6	4	3	4	0	1	0
1	6	3	0	1	1	0	0
1	6	11	1	1	2	0	0
0	2	2	18	1	2	0	1
1	1	3	2	18	5	5	0
0	0	1	2	0	13	7	1
0	1	0	0	0	2	2	0
0	0	0	0	0	1	6	13

20	5	6	1	1	0	1	0
0	6	2	0	0	0	0	1
1	6	12	1	0	0	0	0
1	0	2	17	1	0	0	0
0	0	1	1	21	5	1	0
0	1	0	2	1	11	10	1
0	1	0	1	0	4	5	1
1	2	0	2	1	3	4	11

2-ORDER APPROXIMATION TO ENGLISH

8	1	4	2	2	4	1	2
0	3	0	0	2	0	0	0
1	2	3	3	0	0	2	0
1	0	4	5	0	2	3	0
0	0	0	4	7	2	4	0
1	2	0	3	4	3	5	1
0	2	1	1	1	3	3	3
0	1	0	2	2	2	3	9

17	7	5	2	1	3	3	0
1	6	1	0	1	0	2	1
1	5	7	3	1	0	2	0
5	2	1	11	3	0	1	2
0	1	3	2	12	2	0	1
1	0	0	3	3	13	6	2
1	0	0	0	0	2	6	2
0	0	1	1	1	0	1	15

19	5	3	4	1	3	0	2
0	9	3	2	0	0	1	0
1	3	11	1	1	3	0	0
1	1	2	15	3	1	0	0
0	1	1	0	17	5	2	0
0	0	1	3	1	9	8	1
1	0	0	0	0	2	7	1
0	1	1	1	0	1	1	14

18	4	0	0	0	1	0	2
1	8	1	4	0	0	0	2
2	7	11	0	0	1	1	1
1	1	4	19	2	0	1	1
0	2	2	0	21	8	1	1
0	1	2	0	1	7	5	1
0	0	0	1	1	5	10	1
1	0	1	0	1	2	5	14

22	7	3	1	2	0	0	0
0	8	3	0	1	1	1	0
1	1	11	1	0	0	3	1
0	3	2	23	1	0	2	0
1	3	2	0	21	4	3	0
0	0	0	0	0	14	6	1
0	1	0	1	1	3	6	1
0	0	1	0	1	0	2	20

4-ORDER APPROXIMATION TO ENGLISH

9	5	0	1	1	0	1	0
2	4	2	0	1	0	0	0
1	3	10	5	2	0	0	1
0	2	2	5	0	3	1	0
2	1	2	2	16	6	3	1
0	0	1	2	2	9	5	1
1	2	1	1	0	3	11	0
0	1	1	1	0	1	0	14

19	9	3	4	0	2	3	1
0	9	3	2	2	0	1	0
1	2	11	0	2	2	0	1
0	0	1	15	2	1	2	0
0	1	0	2	17	5	2	1
0	0	0	1	0	7	6	0
1	0	0	0	0	3	3	0
0	0	3	0	0	1	5	17

22	6	3	2	2	2	2	1
2	10	4	1	0	0	0	0
0	3	10	0	1	2	0	0
0	1	1	18	2	0	0	0
0	1	1	2	16	9	3	2
0	0	0	0	1	9	1	1
0	1	1	2	0	1	8	0
0	0	0	0	0	1	5	16

18	10	3	1	2	2	2	1
1	12	5	1	0	1	0	0
1	1	11	1	0	0	1	0
0	0	3	23	2	1	0	0
2	0	0	0	19	6	2	1
0	1	0	0	2	15	4	3
0	0	1	0	2	2	11	3
0	1	2	0	0	0	6	16

19	5	3	0	1	2	1	1
1	12	1	1	1	0	1	3
2	3	15	1	0	1	0	2
0	0	3	22	0	1	2	0
1	0	1	1	23	3	0	1
0	0	0	0	0	18	8	0
0	1	0	0	1	1	13	0
1	0	0	0	0	0	2	17

CONDITION 5

-2-ORDER APPROXIMATION TO ENGLISH

9	5	2	1	1	2	2	1
0	0	1	0	0	0	0	0
0	0	3	1	1	1	0	0
0	1	1	2	1	0	1	0
1	0	1	0	4	2	2	3
1	1	1	1	2	4	1	2
0	0	0	1	1	2	1	0
0	0	1	0	0	1	4	6

8	5	2	1	1	0	0	1
0	1	0	2	1	2	0	0
0	1	3	1	0	0	0	0
0	1	2	6	3	0	2	0
0	2	0	1	7	4	2	1
1	1	1	0	2	2	4	2
0	0	2	0	1	2	1	1
0	0	0	0	0	1	3	8

13	6	1	1	0	1	0	0
0	2	2	1	1	0	0	0
0	1	3	1	0	0	0	0
0	0	4	3	3	1	3	1
0	0	2	4	5	3	2	1
0	0	0	1	3	3	2	1
0	1	0	0	1	0	2	0
1	1	1	1	0	1	3	9

9	7	0	0	1	0	0	0
1	2	3	0	0	0	0	0
1	2	2	2	0	0	0	0
1	1	3	6	4	2	0	0
0	1	1	4	6	7	2	0
1	0	0	1	1	1	1	4
0	0	0	0	0	1	2	0
0	0	1	0	0	0	6	9

10	5	2	0	1	1	1	0
1	2	0	0	0	0	0	1
0	3	4	2	1	1	1	0
0	2	4	7	1	2	2	1
0	3	2	4	7	3	2	1
0	0	0	1	2	4	1	0
1	0	0	0	1	1	1	0
0	0	0	0	0	1	3	11

0-ORDER APPROXIMATION TO ENGLISH

8	6	3	1	2	0	1	1
0	0	1	0	0	0	0	0
1	0	3	3	1	1	0	0
1	2	2	1	2	3	2	1
0	2	1	3	3	2	1	0
0	0	0	1	2	3	0	2
1	0	0	0	0	0	2	1
0	0	0	0	0	2	2	4

10	7	3	0	2	1	0	2
0	0	2	1	0	1	0	0
0	3	5	2	0	1	4	0
0	1	1	5	2	2	1	0
2	2	0	3	3	3	0	0
1	0	0	0	1	3	1	3
0	0	1	1	2	2	1	1
0	0	0	1	1	2	3	4

13	7	4	1	0	1	1	0
0	3	1	0	1	0	0	0
0	1	4	4	1	2	0	2
1	1	1	6	2	1	3	0
0	0	2	1	7	4	1	0
1	0	1	1	1	2	1	0
0	0	1	0	0	5	1	0
0	1	0	0	0	0	3	11

13	3	2	2	2	2	1	0
0	2	1	0	0	1	0	0
0	1	4	2	1	0	0	0
0	3	3	6	1	1	0	1
0	2	2	3	7	4	1	2
0	1	0	1	2	2	3	0
0	1	1	0	1	4	5	0
0	0	0	0	0	1	4	7

12	8	5	2	0	1	2	0
0	2	0	1	3	1	0	0
0	1	2	0	0	1	0	0
0	0	2	7	0	1	2	1
0	1	5	0	11	2	2	1
0	1	0	1	0	4	3	1
0	0	0	1	0	1	3	2
1	1	0	0	0	1	2	6

2-ORDER APPROXIMATION TO ENGLISH

11	8	2	0	2	0	0	1
0	3	2	1	0	0	0	0
1	0	2	2	0	0	0	1
0	0	2	3	1	2	0	0
0	1	0	2	5	3	0	0
0	0	2	1	1	1	5	0
0	0	0	0	0	2	3	0
0	1	0	1	1	0	2	8

11	7	3	2	0	0	0	0
0	3	2	1	1	2	1	1
1	1	5	0	1	0	0	0
0	1	3	7	1	3	0	1
0	1	1	2	8	3	1	0
0	0	0	1	3	5	2	1
1	0	0	0	1	1	5	1
0	0	1	1	0	1	4	8

11	7	3	1	1	0	0	1
2	4	3	0	1	1	0	1
0	3	4	2	2	0	1	0
0	0	2	6	4	0	3	0
0	1	0	2	7	6	1	0
1	0	1	2	0	6	1	0
0	0	0	0	0	1	6	0
0	1	0	0	1	1	2	10

11	4	2	1	0	0	0	0
0	5	1	3	1	0	0	0
1	2	6	4	3	1	1	0
1	0	4	5	0	1	2	0
0	0	1	0	10	5	2	2
0	0	1	1	1	3	3	0
0	0	0	0	0	2	6	1
0	0	0	0	0	2	1	11

9	3	3	0	0	0	1	2
0	3	2	1	4	0	0	0
0	3	5	4	0	0	1	0
0	1	2	7	2	2	0	0
3	0	1	1	8	5	2	0
1	0	1	0	1	6	5	2
0	1	0	0	0	1	3	1
0	0	0	0	1	1	2	8

4-ORDER APPROXIMATION TO ENGLISH

9	7	2	0	0	1	1	2
0	5	0	1	0	0	0	0
1	0	2	1	2	0	0	0
0	0	1	4	2	0	0	1
0	0	1	3	5	5	3	1
0	2	0	0	0	3	6	1
0	0	0	1	2	5	2	0
1	0	1	1	2	1	2	6

15	6	1	1	1	1	0	0
0	5	1	2	0	0	1	0
0	0	8	3	0	0	0	0
0	0	1	3	3	1	2	0
0	1	0	1	6	4	0	0
0	1	1	2	0	4	3	0
0	0	0	1	1	3	6	0
0	0	1	0	0	0	1	13

14	4	0	1	1	1	1	0
0	6	2	1	2	0	0	1
0	2	8	3	0	1	0	0
0	0	1	7	3	0	0	0
0	0	1	1	7	4	2	1
0	1	1	1	0	4	3	0
0	0	0	0	1	3	7	0
0	1	0	0	0	1	2	12

14	6	2	0	0	0	1	1
0	6	3	1	0	0	0	0
0	0	5	2	2	1	0	0
0	1	1	9	4	1	0	0
0	1	2	2	6	4	2	2
0	0	0	1	1	7	6	0
0	1	0	0	2	2	4	2
0	1	0	0	0	0	3	10

14	3	1	1	0	0	0	0
1	8	1	0	0	0	0	0
0	3	10	5	1	0	0	0
0	0	3	7	6	2	2	0
0	0	1	3	8	5	2	1
1	0	0	0	0	8	3	0
0	0	0	0	0	1	7	2
0	0	0	0	0	0	1	10

CONDITION 6

-2-ORDER APPROXIMATION TO ENGLISH

26	8	1	1	0	0	1	1
1	6	1	1	0	1	0	0
0	7	12	4	0	0	1	1
0	3	9	21	3	3	1	0
0	2	1	2	25	8	4	2
3	2	0	1	1	8	3	1
0	1	4	0	0	2	13	1
2	0	1	1	0	4	10	23

22	11	1	0	1	1	0	1
3	6	3	1	0	0	1	0
0	2	10	3	1	0	0	0
0	7	12	29	5	2	1	0
0	4	2	1	24	12	3	1
0	0	0	0	1	11	7	2
0	0	0	0	2	3	10	3
0	1	1	0	0	2	8	21

23	5	2	0	0	0	0	0
0	4	5	0	0	1	0	0
0	6	11	3	0	0	0	0
0	6	16	28	6	0	4	1
0	1	0	1	29	17	3	0
1	3	0	0	0	9	10	1
1	3	0	0	0	5	9	3
2	0	0	0	0	1	5	24

24	9	0	0	0	0	1	0
2	7	0	0	0	0	0	0
0	4	17	0	0	0	0	0
1	1	2	32	4	0	1	0
1	2	6	2	21	9	2	0
0	1	0	1	0	18	10	5
1	0	1	0	0	3	14	0
0	0	1	0	0	2	4	27

22	9	2	1	1	0	1	0
0	12	2	0	0	0	2	1
1	6	24	0	1	0	0	3
1	1	2	31	1	0	1	1
0	2	1	2	28	4	3	0
0	0	1	0	1	19	7	0
0	0	0	1	2	4	13	1
0	0	3	0	0	3	6	20

0-ORDER APPROXIMATION TO ENGLISH

27	12	5	2	4	0	0	0
0	7	0	1	0	0	0	1
1	2	10	2	0	1	1	4
0	3	8	25	2	2	3	2
0	1	4	1	17	9	4	2
0	2	0	0	2	14	9	2
0	0	0	0	1	4	3	1
0	2	1	0	0	2	9	9

25	10	0	1	3	2	1	2
0	7	2	1	1	0	0	3
0	2	15	7	0	0	0	0
3	3	9	19	1	4	3	0
1	4	1	4	27	7	5	1
0	0	0	0	1	14	6	7
0	1	1	0	0	0	8	2
3	0	0	0	0	3	5	11

27	11	4	1	2	4	1	0
0	6	1	2	0	1	0	1
2	8	18	0	0	0	1	0
3	1	5	32	2	1	3	1
0	1	2	0	28	8	2	0
0	0	1	0	1	14	4	0
0	0	0	0	0	4	8	5
0	0	1	0	0	0	10	21

32	9	4	0	0	0	1	1
0	13	9	0	0	0	0	0
0	3	15	1	0	0	1	0
0	4	3	34	3	2	2	1
0	1	0	0	29	5	1	0
0	1	0	0	0	22	8	0
0	1	0	0	0	2	8	3
2	0	0	0	0	1	8	20

26	5	2	0	0	0	0	1
1	11	4	0	0	0	0	0
0	7	17	0	0	0	0	0
1	3	4	31	1	1	1	0
1	2	0	3	32	11	2	0
1	1	0	0	0	16	4	1
0	0	0	1	2	3	16	2
3	2	1	0	0	2	5	27

2-ORDER APPROXIMATION TO ENGLISH

25	14	3	1	1	0	2	0
2	5	5	2	0	0	0	1
1	6	13	6	0	1	1	2
3	0	7	22	2	3	0	1
0	1	4	3	23	3	2	1
0	0	0	1	2	14	8	2
0	1	0	0	3	7	6	1
0	2	0	0	0	2	7	23

26	12	2	1	0	1	2	1
1	9	5	2	0	0	0	0
1	9	17	2	1	0	1	0
0	1	7	27	3	1	1	1
1	0	1	0	31	8	3	0
0	0	0	1	0	21	7	3
2	1	0	0	0	1	10	2
0	0	2	0	0	0	7	20

30	13	0	0	2	0	0	1
0	13	4	0	1	0	1	1
0	3	20	2	1	1	0	0
1	1	5	28	5	2	1	0
0	2	1	2	23	7	0	0
0	0	1	1	1	18	9	0
1	0	0	0	0	6	14	4
1	0	0	1	2	0	6	23

29	4	1	1	0	0	0	0
1	9	5	0	0	0	0	1
1	7	15	2	0	1	1	1
0	3	11	28	3	0	1	0
0	3	1	4	30	6	2	2
0	0	0	0	1	21	8	0
0	1	0	0	0	2	13	2
0	1	0	0	0	1	6	28

29	5	0	0	0	0	0	0
1	9	0	0	0	0	0	0
0	10	23	0	0	0	0	0
2	4	7	32	0	0	1	0
0	1	2	2	36	3	1	0
0	0	1	0	0	29	8	1
0	0	0	0	0	0	15	2
0	0	0	0	0	1	7	31

4-ORDER APPROXIMATION TO ENGLISH

28	9	3	2	1	0	1	0
2	13	5	0	0	0	1	1
0	3	9	5	1	1	0	2
1	1	6	23	7	4	1	0
0	0	4	0	22	6	1	0
0	1	0	0	2	16	7	0
0	0	0	3	0	6	15	3
0	0	0	0	0	0	5	29

28	7	4	0	0	1	0	0
1	21	2	2	1	0	0	0
0	1	18	2	4	0	0	1
0	3	6	29	3	0	0	0
1	1	0	1	22	10	3	1
0	0	0	0	3	18	7	0
0	0	1	1	0	5	13	3
0	0	1	0	1	1	10	26

31	6	1	0	0	0	0	0
0	12	5	1	0	1	0	0
0	5	15	2	4	1	0	0
1	0	5	29	3	0	0	0
0	3	3	2	26	6	0	0
0	1	0	0	2	20	8	1
0	2	1	1	0	8	22	4
0	1	1	0	0	0	5	28

28	5	1	1	0	0	0	0
0	19	5	0	0	0	0	1
0	3	25	0	0	0	1	0
0	1	3	34	0	0	0	0
1	2	0	0	36	4	3	0
0	2	1	0	0	27	5	0
0	0	0	1	0	4	20	1
0	2	0	0	0	0	4	33

31	7	2	0	0	0	1	0
0	16	4	0	0	0	1	1
0	3	20	0	0	1	0	0
0	1	5	33	4	3	0	0
0	0	1	2	31	5	0	0
0	0	0	0	0	26	5	0
0	0	0	0	0	1	22	1
0	4	0	0	1	0	7	32

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