The Effects of Extraneous Lateral Stimulation on Tachistoscopic Pattern Perception

Don Stephen Nice

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THE EFFECTS OF EXTRANEOUS LATERAL
STIMULATION ON TACHISTOSCOPIC
PATTERN PERCEPTION

A Thesis
Presented to
The Faculty of the Department of Psychology
The College of William and Mary in Virginia

In Partial Fulfillment
Of the Requirements for the Degree of
Master of Arts

By
Don Stephen Nice
1973
APPROVAL SHEET

This thesis is submitted in partial fulfillment of
the requirements for the degree of
Master of Arts

Don Stephen Nice
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Approved, May 1973

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ABSTRACT

It has been suggested that the relative accuracy with which stimuli in the left-and-right visual hemifields are perceived is contingent upon specific conditions within the task, relatively stable characteristics within the subject, and certain attentional sets which operate in the processing of information. The present research investigates the effect of preexposural extraneous lateral stimulation upon the error distributions within binary patterns exposed tachistoscopically across the fixation point. It was predicted that a left-to-right postexposural scanning bias would produce fewer errors in the left visual hemifield. This prediction was supported by the results. It was also predicted that a preexposural visual stimulus on the left or right of the visual field would affect the relative number of errors on either side of fixation. A visual stimulus on the right was expected to reduce the number of errors on the right, attenuating the typical left hemifield superiority. The results were significant in the opposite direction and thus did not support this prediction. Instead, the extraneous lateral stimulus increased the number of errors on the side on which it was presented.

In addition, order of report was manipulated and expected to affect the relative number of errors on the left and right of fixation. Fewer errors were expected to occur on the side from which the report originated. This prediction was supported by the results.

The various conditions of lateral stimulation produced significantly different totals of errors and interacted significantly with the order of report conditions. The results were discussed in terms of a postexposural scanning mechanism which is subject to interference from cognitive processing of extraneous lateral stimulation.
THE EFFECTS OF EXTRANEOUS LATERAL STIMULATION ON TACHISTOSCOPIC PATTERN PERCEPTION
Introduction

The present research investigates the influence of extraneous lateral stimulation on certain predispositional or attentional set factors in tachistoscopic pattern perception. Preexposural lateral visual stimuli are manipulated to study the characteristics of relatively stable but cognitively controlled perceptual strategies. These strategies are inferred from the error distributions for the various element positions in the binary patterns which are employed in this study.

The binary patterns consist of eight circles in a horizontal row. Half of these circles are always filled in to make them black dots and half of them are always left unfilled leaving a black ring on a white background. In a bilateral exposure, the binary pattern is exposed across the fixation point so that elements appear in each visual hemifield. When these patterns are exposed, the task of the S is to perceive the pattern of the filled and unfilled circles and to reproduce it on a response sheet. Errors are scored for marking an item which was not filled or for not marking an item which was filled.

Historical Analysis

The accuracy with which multielement stimuli are perceived in the left-and-right visual hemifields has been suggested to be contingent upon

a. relatively stable characteristics within the subject,
b. specific conditions within the task, and
c. certain semistable attentional sets which operate in the processing of information (Harcum, 1970a).
These factors consistently interact to exert varying degrees of influence in any perceptual experience. Therefore, the effects of any one factor can be masked by the influence of other stronger variables.

Although relatively stable characteristics within the subject do exert some influence on the perceptual accuracy of stimuli in the left-and-right visual hemifields, they cannot adequately account for the lateral asymmetries generally found in tachistoscopic pattern perception. Cerebral hemispheric dominance, for example, has been suggested as a stable structural characteristic which neurologically accounts for the differential attensity (clearness or vividness) of a patch of light presented to the left or right side of ocular fixation (Dallenbach, 1923). This neurological hypothesis, however, was tested by Kirssin and Harcum (1967) and failed to obtain the predicted results. Differences in attensity were idiosyncratic in direction and were explained in terms of attention. Their results provided evidence against the hypothesis of lateral dominance, if this can be conceptualized in terms of a stable structural difference, as the determinant of hemifield differences in the perception of the attensity of a patch of light. Since visual patterns of multiple elements consistently showed left superiority, the attensity was not the critical factor.
Moreover, dominance does not appear to be a unitary process. There is enough inconsistency between the measurement of handedness, eyedness, and lateral dominance that this process cannot be conceived simply. Therefore, Harcum (1970a) indicates that one must be cautious about using the concept of dominance for explanatory purposes. In fact, the role of hemispheric dominance is further obscured by the difficulty of predicting which hemisphere is in fact the dominant one for the relevant task for a given subject (Penfield & Roberts, 1959).

Consequently, most contemporary psychologists acknowledge the presence of some stable, structural influences but favor an attentional approach to visual hemifield differences. When binary patterns are tachistoscopically exposed across the fixation point, the distribution of errors closely approximates the bowed serial-position curve obtained in verbal learning studies (Harcum, 1966). This result appears to be produced by the semistable attentional set which operates in the processing of information presented in a multielement array of this type. By manipulating specific variables within the task and observing the subsequent changes in the distribution of errors for different element positions, it is possible to infer the underlying perceptual processes.

**Differential Training**

The publication of Hebb's (1949) heuristic monograph, *The Organization of Behavior* in 1949, stimulated vast amounts of research in the area of visual perception. The concept of motor activity in
the central nervous system producing the phase sequence became fundamental to a number of subsequent theoretical approaches to visual perception.

One of the first empirical investigations of equipotentiality, a theory which conflicted with Hebb's (1949) cell assembly phase sequence theory, was conducted by Mishkin and Forgays (1952). In this study, they found that tachistoscopically presented English words were perceived two and one-half times as often when presented to the right of fixation than words which were presented to the left of fixation. Bilingual subjects, however, could read Hebrew words to the left of fixation more accurately than those presented on the right. They concluded that this result occurs because the reading sequence of English proceeds from left to right, thus selectively training the visual projection areas to perceive English words to the right of fixation. Orbach (1952) demonstrated that Hebrew must be the first learned language to obtain these results.

Forgays (1953) further supported these conclusions by demonstrating that the relative probability of recognition of the stimulus depends on the reading experience of the subject.

Sequential Scanning

Heron (1957), however, presented English words in both fields simultaneously and found superior performance to the left of fixation. He further found that there was no difference between left and right recognition scores when either familiar or nonsense geometric forms were used. To account for these results, he postulated a "postexposural
process" which consists of a sequential scanning of the persisting neural trace of the stimulus after tachistoscopic exposure. The temporal sequence of this attentional process bears a close relationship to the tendencies toward eye movement established by reading. These tendencies closely follow the concept of the phase sequence suggested by Hebb (1949).

Hebb (1949) proposed that through practice in reading temporal-spatial neural networks are built up. The activation of these networks corresponds to the recognition of words.

Activity in the oculomotor areas of the cerebral cortex, present when the observer is reading from left to right and necessarily preceding the overt eye movements, forms an integral part of the neural network [Harcum & Jones, 1962]. Therefore, the incipient eye movement toward the right when a word appears on the right of fixation facilitates the activation of the network. Conversely, when a word is presented on the left of fixation, S does not have a strongly established left directional motor component and no facilitation occurs.

In reading English, the first tendency consists of a sweeping eye movement to the left to fixate at the beginning of a line. The second consists of a series of saccadic jumps from left to right along a line of print (Carmichael & Dearborn, 1947). When alphabetical stimuli are presented in the right field, these two tendencies operate in the same direction. Beginning at the first part of the word or alphabetical series, and continuing along the line require only one
direction of eye movement. For material presented to the left of fixation, however, these two tendencies are in conflict. Under these conditions of successive presentations then, one would predict that the letters would be more accurately recognized when presented in the right visual field. With a bilateral exposure, once again the eye movement tendencies conflict. This conflict generally results with the tendency to move to the beginning of the line or the left, dominating first. This left movement tendency is not inherently dominant but becomes prepotent because of certain habitual methods of perceiving organized material (Camp, 1961). Dyer and Harcum (1966) suggest that this tendency to start at the beginning, presumably at the left end, is established both by a reading habit and by certain physiological qualities such as cerebral hemispheric dominance. This original tendency to the left then results in more letters being recognized on the left side of fixation. Since geometric forms are not read in a unidirectional sequence, they should not be recognized differently in either field.

Terrace (1959) obtained results similar to Mishkin and Forgays (1952) after controlling for preexposural sets. By randomizing both the type of stimulus presented (geometrical and alphabetical) and the side of fixation in which the stimulus appeared, he concluded that the left-right difference for alphabetical material could safely be attributed to a postexposural process.

Further support for Heron's (1957) interpretation of the Mishkin and Forgays (1952) results was provided by Harcum and Finkel
(1963). They presented English words and left-right mirror images of English words to the left and right of fixation. As predicted, the letters of normally presented printed words were more accurately perceived when they appeared to the right of fixation, while the letters of reversed words were more accurately perceived when they appeared to the left. Thus, they concluded that the scanning process tends to proceed from the beginning toward the end of the pattern and that the direction of scan can be determined by the directional characteristics of the stimulus. These results were corroborated and extended by Harcum (1966).

Left Hemifield Superiority

When Harcum (1957a, 1957b) tachistoscopically presented linear binary patterns of filled and open ellipses, he found that Ss consistently reproduced elements to the left of fixation more accurately than elements to the right of fixation. This superior recognition capability for elements in the left visual hemifield has been verified in other studies (Harcum, 1958; Harcum & Dyer, 1962; Harcum, Filion, & Dyer, 1962; Harcum & Friedman, 1963). Unlike multielement letter patterns, binary patterns of open and filled ellipses have no inherent unidirectional perceptual quality. Results indicate, however, that as with alphabetic stimuli, elements to the left of fixation are more accurately reproduced because of a primacy effect resulting from a postexposural left-right scan. Harcum and Dyer (1962) note that such a primacy effect is a general behavioral attribute and not specifically a mechanism of visual perception.
Subsequently, under the rubric of information translation, Harcum (1967b) listed a number of processes common to both serial learning and tachistoscopic pattern perception. These processes included element discrimination, selective analysis of persisting traces, and the organization of information for storage in memory. It therefore becomes evident that the results of tachistoscopic pattern perception cannot be accounted for simply in terms of a postexposural scanning mechanism.

A good deal of evidence indicates that a preexposure set may influence perceptual accuracy (Camp & Harcum, 1964; Haber, 1966; White, 1969). Camp and Harcum (1964) found that when specific pattern orientation relative to fixation was unknown prior to exposure and when more than half of the elements appeared to the left of fixation, the usual tendency for greater accuracy for elements at the left could be overcome. They conclude that a subject clearly brings a response set to the experiment which predisposes him to respond perceptually in a fixed manner, i.e., left to right for English. If such a predisposition is not appropriate for a particular situation, a previously subordinate perceptual response emerges to dominate behavior (Camp & Harcum, 1964).

Order of Report

Harcum (1965) demonstrated that prior knowledge of isolation is critical for an isolation effect in perception. He attributed this finding to the selective distribution of attention among stimulus elements. He further argued that if exposure duration is not
sufficiently long to permit the development of the selective perception, then the selectivity must be provided by preexposure information. Ayres (1966) provided such preexposure information to Ss by instructing them to report in a given sequence before the stimulus pattern was presented. However, he did not discuss his results in terms of modifying perceptual strategies, and concluded that left hemifield superiority was an artifact of order of report. Harcum and Friedman (1963) used tachistoscopic recognition of binary patterns to compare the performance of American and Israeli subjects. Their results indicated that when permitted optional responding orders, the Americans showed left hemifield superiority and the Israelis showed right hemifield superiority. This result would, of course, be predicted on the basis of the Mishkin and Forgays' data. The crucial finding with regard to predispositional factors, however, was that when the American Ss knew before the exposure that a right-to-left sequence of reporting was to be required, they showed a strong right superiority. Thus, when the American was instructed to respond from right to left, he showed right superiority to the same or greater degree than the Israeli showed without instructions.

Harcum, Hartman, and Smith (1963) obtained similar results using all English speaking subjects. They concluded that the effects of responding sequence alone cannot account for the hemifield differences. A perceptual factor apparently corresponds to a sequential analysis of the memory traces of the tachistoscopic exposure. This factor is influenced by the set of the S to respond in a particular
sequence. Winnick and Dornbush (1965) reached similar conclusions when they succeeded in using instructional sets to set up directional tendencies leading to right-left differences in the ease of identification of words. As Harcum (1967b) has pointed out, any number of stimulus variables, subject variables, or response variables can influence the order of perceptual processing or scanning of the elements. It seems logical, therefore, that a number of preexposure manipulations might predispose Ss toward scanning in a particular sequence.

**Sensory-Tonic Field Theory**

Werner and Wapner (1952) in their sensory-tonic field theory also cogently argue that the perceptual process is not purely sensory.

Since any neuro-physiological entity is neither sensory nor motor but a dynamic process prior to both, it may be affected in a similar way by stimulation through the receptors, as well as by direct stimulation of the muscles. Thus, perception may be affected equivalently by various kinds of sensory stimulation and direct muscular changes.

Through various experimental designs, investigators have demonstrated that changes in organismic states are reflected in changes in perception. One method of influencing the state of the organism is through extraneous stimulation, i.e., any stimulation to the organism which comes from a source other than the object tested. By manipulating electrical stimulation to either side of the neck and auditory stimulation on either side of the head, Werner, Wapner, and Chandler
(1951) demonstrated that extraneous stimulation influenced the perception of the vertical.

Postexposural Eye Movements

In a somewhat similar manner, Hebb (1949) in a fundamentally neurological context, discussed the importance of eye movements or their underlying neural activity, in visual perception. Walker and Weaver (1940) have shown direct control of eye movement by peripheral stimulation of the visual cortex. There is direct evidence for the relevance of incipient eye movements and their relation to reproduction accuracy for visual stimuli tachistoscopically exposed to the right and left of fixation (Bryden, 1961; Crovitz & Daves, 1962). Accuracy is greater for the stimulus elements on the side of fixation toward which the first postexposural eye movement is directed. Presumably, attention factors in the perceptual process are related to the motor activity in the nervous system which produces, and necessarily precedes, the overt eye movements (Harcum & Finkel, 1963). In view of the fact that an extraneous stimulation, such as peripheral stimulation of the visual cortex, controls eye movements and presumably the preceding motor activity in the nervous system, this extraneous stimulation must also exert some influence upon the attentional factors in the perceptual process. This influence should be manifested in a tendency to begin the postexposural scan of a visual array from the direction of the extraneous stimulus and thereby reduce the errors in that hemifield.
Extraneous Lateral Stimulation

In order to test this assumption, Nice (1973) investigated the effects of extraneous, lateral auditory stimulation on the distribution of errors within tachistoscopically exposed binary patterns. The patterns consisted of eight circles in a horizontal row, in which four were blackened in to form different patterns. S was emphatically instructed to keep his eyes on the fixation cross which registered with the center of the pattern. The extraneous lateral stimulation consisted of a .5 second buzzer presented on either the left, or right, or both sides of S simultaneously. To ensure that S was attending to the buzzer, he was required to press a key with the corresponding hand. This, in turn, exposed the target for .1 seconds. The sequence in which the elements were reported was neither controlled nor recorded. The purpose of the buzzer was not explained to S. Under each buzzer condition, 20 trials were conducted in random order for each of the 30 Ss. The prediction that increased stimulation to one side facilitates perception for stimuli in that hemifield because S's attention is drawn to it was confirmed by the significant interaction between buzzer condition and the number of errors in each hemifield. Although the typical left superiority occurred under all buzzer conditions, it was attenuated, as predicted, when the buzzer was presented on the right alone.

These results indicate a strong left superiority and support the conclusion that the motor habits discussed by Heron (1957) do have
primacy over other perceptual mechanisms in this type of task. The strong left-right scanning tendency is not easily shifted by external manipulation. The results, however, indicate that an extraneous auditory stimulus in conjunction with a motor response does influence the attentional factors in the perceptual process. The significant interaction suggests that the postexposural scan was drawn to the side of the extraneous stimulation. Of course, in this experiment it is not possible to conclude whether the auditory stimulus, the motor response, or the additive effect of both was responsible for the results. These results do indicate, however, that perception is selective and that it can be modified by extraneous stimulation.

Another possible explanation of the results, however, may be in terms of eye movement artifact. Due to the latency between the onset of the buzzer and the stimulus exposure, eye movement may have occurred. The eye movement artifact has presented a problem for much research in visual perception. Even though Ss were twice instructed to maintain fixation, and postexperimentally verbally denied that they had made any deviation from fixation, it is still possible that they moved their eyes before the stimulus pattern was presented. This, however, is not believed to be the case. A consistent gross eye movement toward the extraneous stimulus would result in an exposure which would essentially be presented in primarily one hemifield at a time. Results from this type of presentation typically show dramatic differences in error distributions for the opposite hemifields. If this artifact were responsible for the
results, one would expect that the right buzzer condition, which would be tantamount to an exposure presented primarily to the left of fixation, would produce a strong, positively skewed error distribution with fewer errors occurring in the element positions on the right. Instead, these data were negatively skewed, indicating left superiority. Further, Harcum (1970b) argues from empirical evidence that differences in perceptibility of elements within tachistoscopic patterns are a function of intrinsic organizational processes and not retinal sensitivity.

Another possible artifact in this study may have been the order-of-report sequence. Because Ss were allowed to respond in any sequence, the hemifield differences may have occurred because Ss typically respond in a left-to-right manner, thus recording left hemifield responses first before the visual impressions decay. Lawrence and LaBerge (1956) suggest that since all memory for the stimulus is slowly fading, whatever is reported first will be more accurate than later reported items. This, however, does not explain the interaction effect between responding order and side of extraneous stimulation. There is no evidence which indicates that external stimulation influences order of report.

Harcum, Hartman, and Smith (1963) have concluded that the effects of responding sequence alone cannot account for hemifield differences. Rather, a perceptual factor apparently corresponds to a sequential analysis of the memory traces of the tachistoscopic exposure. These conclusions are in accord with a number of previous
Although the results of this experiment were significant and in the predicted direction, it appears that they may have been contaminated by the artifacts of eye movement and order of report. Therefore, corroborative evidence from different and more rigorously controlled investigations is required.

**Purpose of the Study**

The present study was conducted to extend and further elucidate previous findings on the effects of extraneous lateral stimulation on the distribution of errors within tachistoscopic patterns (Nice, 1973). The modality of the preexposure, extraneous lateral stimulation is changed from audition to vision to allow possible generalization of the perceptual effects across modalities. In addition, the confounding effects of potential artifacts are minimized by certain methodological improvements.

The problem of preexposural eye movements is reduced by the fact that the combined duration of both the extraneous visual cue and the binary pattern is .15 seconds— which is slightly below eye movement latency. In addition, the order of report is controlled and counterbalanced over all conditions. The present study, therefore, introduces more rigorous control over extraneous variables while investigating the effects of extraneous lateral visual stimulation on the perception of tachistoscopic patterns.

If the elements of tachistoscopically exposed binary patterns
are sequentially processed temporally in a left-to-right fashion, it is expected that over all conditions fewer total errors will be produced on the left side of the fixation than on the right. Also, if a preexposural extraneous visual stimulus does draw attention to the side on which it is presented, it is expected that the extraneous visual stimulus will interact with the side of fixation. Although extraneous visual stimulation is not expected to negate totally the typical left-to-right scanning bias, it is predicted that a preexposural stimulus on the right will reduce right hemifield errors. Finally, it is predicted that the errors on either side of fixation will interact with the order in which the pattern is reported. When responding from left to right, it is expected that a responding primacy effect will favor the elements on the left side of fixation. This left superiority should be reduced, however, when the order of report is from right to left.
Method

Subjects. Undergraduates from the College of William and Mary (10 men and 10 women) participated in the study. All Ss had 20-20 vision, or vision corrected to 20-20, and were paid $1.50 for their participation.

Apparatus. A Scientific Prototype, model GB, three channel tachistoscope was used in the study. The extraneous visual stimulus consisted of a vertical bar 7 mm. wide and 5.1 cm. high with alternating black and white horizontal stripes 7 mm. wide. This preexposural visual stimulus was presented 1.8 cm. beyond the end of the subsequently illuminated binary pattern and 6.6 cm. on either side of fixation.

The binary patterns consisted of eight circles in a horizontal row. Half of the circles were always filled in and half were always unfilled to form different patterns. The patterns measured 9.6 cm. in length. Each circle measured 7 mm. in diameter with an inter-item space of 6 mm. With each of the circles being filled equally often, 20 patterns were used. The series of patterns was presented in the following sequence: normal orientation, inverted, normal, inverted. Thus, a total of 80 trials were conducted for each S.

Field illumination was held constant at 35 ft-L. The exposure durations for the preexposural visual stimulus and the binary pattern were .05 seconds and .1 seconds, respectively.

A Guardian delay timer was used to postexposurally illuminate
one of two vertically positioned, incandescent, 3-watt bulbs labeled "Right" and "Left," respectively, to indicate the required order of report for each trial. The delay time was set to illuminate the bulb 2 seconds after the onset of the stimulus. Response sheets consisted of two columns of response blanks with 10 in each column. Each response blank consisted of a row of eight unfilled circles.

Procedure. Each S was seated in front of the three channel tachistoscope and read the following instructions:

This is a study in visual perception. I would like for you to look in the aperture and notice the white visual field with the black fixation cross at its center. During each trial, it is essential to the experiment that you keep your eyes on this cross. It will also help you to see what is being presented.

The targets you will reproduce will consist of eight circles in a horizontal row. Half of these circles will always be blackened in and half will always be unfilled to form different patterns. As soon as the target has been flashed, reproduce the target on your answer sheet by placing a slash through those circles which were blackened in, leaving the unfilled circles unmarked. After every exposure, a light labeled either left or right will come on to indicate the side from which to begin marking the circles. If the light labeled "right" comes on, begin on the right side of the row of circles, and moving from right to left, mark those circles which were filled in on the target. If, on the other hand, the light labeled "left" comes on,
begin with the left-most circle, and moving from left to right, mark those circles which were filled in on the target. Mark the circles only in the sequence in which the light indicates. Do not go back, or change a mark once you have made it.

In order to confirm that you are looking at the cross when a target is exposed, a vertical bar with horizontal stripes may, or may not, be flashed on either the left, or right, or both sides of the visual field just prior to the exposure of a target. After you have reproduced the target, place a check mark on the side, or sides of your reproduction on which a bar appeared. If the bar did not appear, do not make a check mark. As soon as you have completed the response, and indicated the side on which the bar was presented, look at the black fixation cross again. I will then say "Ready" and the next target will be flashed. Before we start, I would like to reemphasize the importance of keeping your eyes on the fixation cross during each trial. If, for any reason, you were not looking there when the target appeared, or if anything else occurred to spoil the trial, such as a blink, please let me know so that we can discard that observation.

Do you have any questions before we begin?

S was then given a practice trial to familiarize him with the apparatus and procedure. As soon as S was in position and looking at the fixation cross in the center of the fixation field, E said "Ready" and exposed the target. The extraneous visual stimulus appeared first on the left or right or both or neither side of the
visual field for .05 seconds. This was replaced by the binary pattern which was exposed for .1 seconds. The fixation field then reappeared. After a 2 second delay, the order of report light came on to indicate the sequence in which S was to report the pattern. S then made his response, indicated the side on which the bar was presented, and repositioned himself for the next trial. The order of report and extraneous visual stimulus were randomly presented, and counterbalanced in such a manner that left-and-right order of report were equal under each of the four extraneous stimulus conditions. In addition, an equal number of trials (viz., 20) were conducted under each condition for each S.
Results

A two-by-two-by-four analysis of variance with repeated measures on all factors was computed on the error scores on either side of fixation under each condition of order of report for each of the four conditions of extraneous visual stimulation. These results are presented in Table 1.

A significantly fewer number of errors occurred on the left side of fixation ($F = 32.87, df = 1/19, p < .001$). This result is presented in Figure 1. In addition, the main effect of total errors as a function of the condition of the extraneous visual stimulation was significant ($F = 10.75, df = 3/57, p < .001$).

A posteriori pairwise comparisons were made using Tukey's HSD (Honest Significant Difference) test. The means and differences are presented in Table 2. All pairwise comparisons were significant except the conditions in which the preexposural cue was presented on the left and when it was presented on both sides simultaneously. The errors per condition were ranked in descending order as follows: both, left, right, neither. These results are presented graphically in Figure 2.

In addition to these significant main effects, all two-way interactions were significant. The extraneous stimulation condition interacted significantly with the order of report ($F = 4.18, df = 3/57, p < .01$). Multiple $t$ tests for related samples were computed on the errors between each condition of order of report within each condition.
### Table 1

**Analysis of Variance Summary Table for Errors in Pattern Perception for Each Condition of Order of Report Under Each Condition of Extraneous Stimulation**

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Extraneous Stimulus)</td>
<td>3</td>
<td>191.31</td>
<td>10.75 ***</td>
</tr>
<tr>
<td>B (Order of Report)</td>
<td>1</td>
<td>3.20</td>
<td>1.16</td>
</tr>
<tr>
<td>C (Side of Fixation)</td>
<td>1</td>
<td>561.80</td>
<td>32.87 ***</td>
</tr>
<tr>
<td>A X B</td>
<td>3</td>
<td>76.21</td>
<td>4.18 **</td>
</tr>
<tr>
<td>A X C</td>
<td>3</td>
<td>72.02</td>
<td>4.13 *</td>
</tr>
<tr>
<td>B X C</td>
<td>1</td>
<td>460.80</td>
<td>60.82 ***</td>
</tr>
<tr>
<td>A X B X C</td>
<td>3</td>
<td>5.02</td>
<td>0.36</td>
</tr>
<tr>
<td>Subjects</td>
<td>19</td>
<td>59.89</td>
<td></td>
</tr>
<tr>
<td>Error A</td>
<td>57</td>
<td>17.80</td>
<td></td>
</tr>
<tr>
<td>Error B</td>
<td>19</td>
<td>20.52</td>
<td></td>
</tr>
<tr>
<td>Error C</td>
<td>19</td>
<td>17.09</td>
<td></td>
</tr>
<tr>
<td>Error A X B</td>
<td>57</td>
<td>18.24</td>
<td></td>
</tr>
<tr>
<td>Error A X C</td>
<td>57</td>
<td>17.44</td>
<td></td>
</tr>
<tr>
<td>Error B X C</td>
<td>19</td>
<td>7.58</td>
<td></td>
</tr>
<tr>
<td>Error A X B X C</td>
<td>57</td>
<td>13.82</td>
<td></td>
</tr>
</tbody>
</table>

* p<.025
** p<.01
*** p<.001
FIGURE 1
MEAN ERRORS ON THE LEFT AND RIGHT OF FIXATION
TABLE 2

COMPARISON OF DIFFERENCES OF MEAN ERRORS IN PATTERN PERCEPTION FOR EACH PREEXPOSURAL STIMULUS CONDITION

<table>
<thead>
<tr>
<th>Left ($b_1$)</th>
<th>Both ($b_2$)</th>
<th>Right ($b_3$)</th>
<th>Neither ($b_4$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b_1$ 69.10</td>
<td>---</td>
<td>7.4 **</td>
<td>13.05 **</td>
</tr>
<tr>
<td>$b_2$ 68.90</td>
<td>---</td>
<td>7.2 **</td>
<td>12.85 **</td>
</tr>
<tr>
<td>$b_3$ 61.70</td>
<td>---</td>
<td>---</td>
<td>5.65 *</td>
</tr>
<tr>
<td>$b_4$ 56.05</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

* $p<.05$
** $p<.01$
FIGURE 2

MEAN ERRORS FOR EACH CONDITION OF PREEXPOSURAL STIMULATION
MEAN ERRORS

<table>
<thead>
<tr>
<th>BOTH</th>
<th>NEITHER</th>
<th>RIGHT</th>
<th>LEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>60</td>
<td>50</td>
<td>40</td>
</tr>
</tbody>
</table>

SIDE OF EXTRANEOUS STIMULATION
of preexposural stimulation. The Dunn Multiple Comparison Test was used to derive the critical value of $t$.

The only significant difference between order-of-report conditions within each preexposural stimulus condition occurred when no cue was presented ($t = 3.6, df = 19, p < .01$). In this condition the right-to-left order of report was superior to the left-to-right reporting sequence. These results are presented in Figure 3.

In addition, the order of report interacted significantly with the number of errors on the left and right of fixation ($F = 60.82, df = 1/19, p < .001$). A left-to-right reporting sequence produced a marked left superiority. A right-to-left reporting sequence, however, attenuated this effect and produced an equal distribution of errors on either side of fixation. These results are presented graphically in Figure 4.

Finally, the extraneous stimulation interacted significantly with the number of errors on either side of fixation ($F = 4.13, df = 3/57, p < .025$). This interaction, however, was not in the predicted direction. The mean errors for each preexposural stimulus condition for each side of fixation are presented in Figure 5. A significant left hemifield superiority was maintained when the preexposural extraneous stimulus was presented on both sides ($p < .025$), on the right ($p < .01$), and on neither side ($p < .01$). However, when the preexposural cue was presented in the left visual field, a slight right superiority was produced. A plot of the percentage of errors for each element position is presented in Figure 6. The curve for the
FIGURE 3

MEAN ERRORS FOR EACH CONDITION OF ORDER OF REPORT

UNDER EACH CONDITION OF EXTRANEous STIMULATION
MEAN ERRORS

ORDER OF REPORT
LEFT TO RIGHT
RIGHT TO LEFT

MEAN ERRORS

SIDE OF EXTRANEOUS STIMULATION
NEITHER RIGHT LEFT BOTH
FIGURE 4

MEAN ERRORS ON THE LEFT AND RIGHT OF FIXATION

UNDER EACH CONDITION OF ORDER OF REPORT
MEAN ERRORS

SIDE OF FIXATION

LEFT
RIGHT

ORDER OF REPORT

LEFT TO RIGHT
RIGHT TO LEFT

MEAN ERRORS
FIGURE 5

MEAN ERRORS ON THE LEFT AND RIGHT OF FIXATION
UNDER EACH CONDITION OF EXTRANEOUS STIMULATION
MEAN ERRORS

SIDE OF FIXATION

LEFT □
RIGHT □

SIDE OF EXTRANEOUS STIMULATION

MEAN ERRORS

BOTH
NEITHER
RIGHT
LEFT

SIDE OF EXTRANEOUS STIMULATION
FIGURE 6
PERCENTAGE OF ERRORS IN EACH ELEMENT POSITION UNDER EACH CONDITION OF EXTRANEOUS STIMULATION
Percentage of Errors

Side of Extraneous Stimulus

Left
Both
Right
Neither

Element Position
condition in which the cue was presented on the right is far more skewed to the right than the curve for the left condition and appears very similar to the curve generated when no extraneous stimulus was presented.

Due to the differences in total errors under the various conditions, a plot of the percentage of errors within each extraneous stimulus condition for each element position presents a somewhat more intelligible picture. These results are presented in Figure 7.

In view of the potentially large weighing contributed by Ss committing a greater number of total errors, a treatment-by-treatment-by-subjects analysis of variance was computed on the percentage of errors on the left of fixation for each condition of order of report under each of the four conditions of extraneous stimulation. These results are similar to those obtained in the analysis of the total errors and are presented in Table 3.

A treatment-by-treatment-by-subjects analysis of variance was computed on the accuracy of the Ss in reporting the side on which the preexposural stimulus actually occurred in each of the four conditions and is presented in Table 4. The differences in correct recognition of the preexposural stimulus were significant ($F = 3.21, df = 3/57, p < .05$). A Tukey's HSD test was used to make post hoc multiple comparisons between the means. As presented in Table 5, significantly more errors occurred in the recognition of the preexposural cue when it was presented in both sides of the visual field simultaneously ($p < .05$) than when it was presented only in
FIGURE 7
PERCENTAGE OF ERRORS IN EACH ELEMENT POSITION WITHIN EACH CONDITION OF EXTRANEOUS STIMULATION
Percentage of Errors Within Conditions

Side of Extraneous Stimulus

Left
Both
Right
Neither

Element Position

Percentage of Errors Within Conditions

18 16 14 12 10 8 6 4 2

1 2 3 4 5 6 7 8
TABLE 3

ANALYSIS OF VARIANCE SUMMARY TABLE FOR PERCENTAGE OF ERRORS ON THE LEFT OF FIXATION FOR EACH CONDITION OF ORDER OF REPORT UNDER EACH CONDITION OF EXTRANEOUS STIMULATION

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Extraneous Stimulus)</td>
<td>3</td>
<td>401.42</td>
<td>4.14 *</td>
</tr>
<tr>
<td>B (Order of Report)</td>
<td>1</td>
<td>2125.04</td>
<td>21.93 ***</td>
</tr>
<tr>
<td>A X B</td>
<td>3</td>
<td>26.48</td>
<td>.27</td>
</tr>
<tr>
<td>Residual Error</td>
<td>133</td>
<td>96.89</td>
<td></td>
</tr>
</tbody>
</table>

* p<.05  
*** p<.001


<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
</table>
| Column              | 3  | 33.42  | 3.21 | *
| Rows (Subjects)     | 19 |        |      |
| Residual Error      | 57 | 10.42  |      |

* p<.05

TABLE 4

ANALYSIS OF VARIANCE SUMMARY TABLE FOR THE RECOGNITION OF THE PREEXPOSURAL STIMULUS UNDER EACH CONDITION OF PRESENTATION


**TABLE 5**

**COMPARISON OF DIFFERENCES OF MEAN ERRORS ON THE RECOGNITION OF THE PREEXPOSURAL STIMULUS IN EACH CONDITION OF PRESENTATION**

<table>
<thead>
<tr>
<th></th>
<th>Both (b₁)</th>
<th>Left (b₂)</th>
<th>Neither (b₃)</th>
<th>Right (b₄)</th>
</tr>
</thead>
<tbody>
<tr>
<td>b₁</td>
<td>4.85</td>
<td>2.35</td>
<td>2.65</td>
<td>2.70 *</td>
</tr>
<tr>
<td>b₂</td>
<td>2.50</td>
<td>---</td>
<td>.30</td>
<td>.35</td>
</tr>
<tr>
<td>b₃</td>
<td>2.20</td>
<td>---</td>
<td>---</td>
<td>.05</td>
</tr>
<tr>
<td>b₄</td>
<td></td>
<td></td>
<td></td>
<td>---</td>
</tr>
</tbody>
</table>

* p<.05
the right visual field.
Discussion

Postexposural Scan

One of the major results of this study was to provide further evidence in support of a postexposural scanning mechanism. As expected, significantly fewer errors were produced on the left of fixation than on the right. This strong left superiority suggests the operation of a postexposural process which functions very similar to actual eye movements during reading and corroborates previous work done in this area (Harcum, 1958; Harcum & Dyer, 1962; Harcum, Filion, & Dyer, 1962). As order of report was controlled in this study, the effect does not appear to be caused by an artifactual primacy effect induced by consistently reporting in a left-to-right sequence.

Order of Report

Ayres (1966) argued that a postexposural process was not needed to account for previous findings of left hemifield superiority. Using tachistoscopically exposed binary patterns, he succeeded in eliminating the typical left superiority by preexposurally instructing Ss to respond in a given sequence. This preexposural cuing procedure produced left hemifield superiority for left-to-right order of report and right hemifield superiority for a right-to-left reporting sequence. Ayres, however, neglected to consider the powerful effect these preexposural instructions may have had on the Ss' perceptual strategies. Further, Harcum (1967a) argues that the proposition of
Experimental artifact is not justified by the data which Ayres presented. The postexposural reporting instructions employed in the present study could not have influenced the direction of the S's sequential perceptual processing, and thereby obtained results consistent with a postexposural left to right scanning hypothesis.

The strong, significant interaction between the errors on the left-and-right side of fixation and the order of report was in the predicted direction and provided additional support for the postexposural scan. When S reports items in a left-to-right sequence, he is reporting in a direction which is consistent with the temporal sequence in which they were scanned; thus, the errors on the left are reduced both by a primacy effect of scanning (more efficiently encoding the first items in a series) and a primacy effect of reporting (retrieving the information before it decays). In addition, the errors on the right are increased by decay and proactive inhibition induced by reporting the items on the left first. Therefore, when a left-to-right order of report is given, a strong left hemifield superiority is maintained. On the other hand, when S reports items in a right-to-left sequence, the primacy effect of early report favors the items on the right while the effects of decay and proactive inhibition reduce the typically prepotent effect of the left-to-right scanning bias. Therefore, when a right-to-left order of report is required, the net result is an even distribution of errors on either side of fixation.
Eye Movement Artifact

In addition, the left hemifield superiority in this study does not appear to be an eye movement artifact. Throughout the instructions, Ss were repeatedly told to keep their eyes on the fixation cross. All Ss were then postexperimentally asked if they had any difficulty at all keeping their eyes on the fixation cross. No one indicated that he did. Further, a consistent eye movement to the left would appear to be necessary if the left superiority were produced by an eye movement artifact. It would seem that such a movement would significantly decrease the accuracy of reporting the extraneous visual cue when it appeared on the right and increase the accuracy when it appeared on the left. The data presented in Table 5, however, indicate that recognition was actually better when the extraneous visual cue appeared on the right. The only significant decrease in recognition of the cue occurred when it appeared in both visual fields simultaneously.

One further argument against the influence of an eye movement artifact is the exposure duration of the stimuli. The combined duration of both the extraneous visual cue and the binary pattern was .15 seconds which is slightly below eye movement latency. If, however, the Ss were jumping fixation toward the extraneous visual stimulus, the perceptual errors in the binary pattern should be reduced on the side of fixation on which the extraneous stimulus was presented. The data in Figures 5, 6, and 7, however, indicate just the opposite interaction. Errors were increased on the side of
fixation on which the prior stimulus was presented.

**Extraneous Lateral Stimulation**

This significant interaction in the direction opposite that which was predicted necessitates some post hoc theorization and integration with other related results. Certainly, the proposition that the postexposural scan is drawn to and initiates from the direction of the extraneous visual stimulation must be rejected. An increase in errors in the hemifield in which the extraneous stimulation was presented is not consistent with this hypothesis. A postexposural scan originating from the side opposite the preexposural visual stimulus must similarly be rejected. Aside from the fact that this is theoretically inconsistent with the evidence presented previously in the paper, it fails to account for the significant differences in errors under various conditions of preexposural stimulation. When a prior stimulus is presented on the right, significantly more errors are produced than when no prior stimulus is presented. Similarly, when an extraneous stimulus is presented on the left or both sides, significantly more errors occur than when it is presented on the right or when no extraneous stimulus is presented. If the absence of prior stimulation produces a typical left-to-right scan and if a prior stimulus on the right produces that identical scan, the error distributions for each of these conditions should be identical. They are not. In addition, there is no evidence which indicates that a right-to-left scan is inferior to a left-to-right scan, but the errors under the left-and-right conditions of extraneous stimulation are
significantly different.

Cognitive Lateral Inhibition

In view of the disruptive effects of the extraneous stimulation, as evidenced by the progressively increasing error rates under various conditions of preexposural stimulation, a lateral inhibition in pattern perception induced by the processing of the visual extraneous stimulus must be considered. When two stimuli are presented in rapid succession, the reaction time (RT) for the second stimulus is typically increased when compared to the RT to the second stimulus when it is presented alone (Smith, 1967). Findings of Adams and Chambers (1962) and of Reynolds (1966) further indicate that RT is delayed significantly longer if the first response represents a disjunctive or a choice reaction. In addition, Davis (1965) has found that there are no delays if it does not have to select a response to the first stimulus. In the present study, S responded to the first stimulus as well as the second. These studies appear to support a single channel processing mechanism, either central or peripheral, which successively limits either the sensory processing of information or the response selection. The majority of evidence favors the operation of a single channel mechanism which functions to select appropriate responses (Davis, 1965; Hick, 1948; Hick & Bates, 1950; Vince, 1948; Welford, 1959). Therefore, when Ss are presented with two rapidly successive stimuli, both of which require responses, the second stimulus must be "held in store" until the first decision is made.

Kristofferson (1967) has conceptualized attention as a limited
capacity switching mechanism which is responsible for controlling the flow of information. He proposes that information is fed into the central processor from the display areas associated with the various sensory input channels. Attention is then aligned with messages arriving over various input channels. A message arriving over an unattended channel must be delayed until the attention mechanism switches to its channel. This latency depends upon the nature of the task and the practice of the S. He further proposes a gross sorting of inputs and a short-term storage at a level prior to the central attention mechanism.

This short-term storage component is very similar to Sperling's (1960) visual information storage. By using a partial report technique, Sperling found that initially there is a great deal more information available to the S than he can report after a few seconds. The image of a briefly exposed stimulus, therefore, presents a rapidly fading trace which must be rehearsed to be retained in memory for subsequent retrieval. Any delay in rehearsal, encoding into a longer term storage, or central attention, regardless of the terminology, may result in a loss of information. Therefore, the delay imposed by the processing, response selection, and rehearsal of a preexposural extraneous stimulus may increase the total number of errors in pattern perception under the various conditions of extraneous lateral stimulation. This, however, does not account for the interaction between the errors on the left and right of fixation and the extraneous stimulus condition.
In order to discuss this interaction, one must consider the perceived temporal order of the two stimuli presented in close temporal succession. Rutschmann (1966) has reported that uncertainty of temporal order of flashes delivered at various asynchronies to the fovea and periphery of the eye is maximal when the onset of the peripheral flash is first. In addition, an onset asynchrony of 50 milliseconds is well within the maximal range of temporal uncertainty. This perceived simultaneity of temporally different stimuli is known as the psychological moment. In fact, many Ss in the present experiment reported that the preexposural stimulus appeared to be exposed simultaneously with the pattern. It may, therefore, be assumed that there was a great deal more perceptually simultaneous information in the hemifield in which the preexposural stimulus was presented. This increased lateral information input, although temporally discrete in physical terms, may interfere with lateral processing and produce a cognitive lateral inhibition effect. This seems particularly viable in view of the fact that Ss could not immediately respond to the extraneous stimulation but had to retain the selected response in memory while processing the pattern information.

With a left-to-right postexposural scanning, this lateral interference would be much more disruptive if it occurred in the left hemifield as opposed to the right. Since the performance on the elements to the right of fixation is typically reduced by a delay in encoding, the further effects of interference are relatively minimal.
In addition, the lateral interference from the extraneous stimulus on the right may dissipate somewhat by the time those elements are processed. Lateral interference on the left, however, probably has not dissipated when the elements on the left are being processed. In addition, a disruption in the processing of these crucial elements may interfere to a greater extent with the overall organization of information for storage in memory. These proposals are consistent with the differential error rates and the general shapes of the curves under the various conditions of preexposural stimulation. They are, however, post hoc and, therefore, in need of subsequent verification.

The remaining significant interaction occurred between the order of report and the condition of extraneous stimulation. Although the left-to-right order of report was somewhat superior when the extraneous cue was presented in either the left-or-right hemifield and the right-to-left report was slightly superior when the cue was presented in both hemifields simultaneously, none of these differences within conditions of extraneous stimulation were significant. However, when no extraneous stimulus was presented, significantly fewer errors occurred when S reported in a right-to-left sequence than when he responded from left to right. Since the typical responding order in the English language is from left to right, this finding is counterintuitive.

One possible interpretation may be that when no extraneous stimulus is presented and the stimulus array is sequentially processed
in the postexposural left-to-right scan, the elements on the left obtain a higher item strength relative to the elements on the right. Battig, Allen, and Jensen (1965) have presented evidence contrary to the prevailing notion that order of free recall directly reflects item strength. They demonstrated that the first items to be recalled on a particular trial tended to be those which were not recalled correctly on the preceding trial. The most efficient method of reporting, therefore, seems to be to report items of relatively low strength first so that they will not be lost by decay and proactive interference induced by reporting other items first. Relatively strong items, on the other hand, can still be accurately reported later in free recall. These results were subsequently corroborated by Battig (1965). It is possible, therefore, that when there is no interference from extraneous lateral stimulation, the most efficient strategy is to report the relatively weak items on the right first and maximize the accuracy of these tenuous, fading traces. The strong items on the left would remain relatively unaffected by this reporting sequence.

This interaction, on the other hand, may be an experimental artifact produced by randomly embedding the control condition (no extraneous stimulation) within the experimental conditions. Anticipating a preexposural cue, S may have postexposurally searched the left and then the right sides of the target. This postexposural search toward the right may have facilitated responding in a right-to-left sequence. In any case, the effect was small and would probably
be very difficult to replicate.

Conclusions

Although the primary intent of this investigation was to investigate the facilitative effects of lateral extraneous visual stimulation on selective attention in tachistoscopic perception of binary patterns, the results indicated a lateral interference effect. Aside from the modality of the extraneous stimulus and some methodological improvements, the only basic difference between the present study and Nice (1973) was the timing of the response to the extraneous cue. In the study using an auditory cue, Ss were required to press a key with the hand corresponding to the side of stimulation prior to the presentation of the target pattern. In the present study, however, Ss were required to retain the response to the extraneous stimulus in memory until after they had responded to the binary pattern. It is conceivable that lateral facilitation occurred in the first study because the response to the auditory cue was made before the pattern was exposed thereby releasing Ss from proactive inhibition. There were no significant differences in total errors as a function of the extraneous auditory stimulus condition. However, in the present study total errors increased significantly under various conditions of extraneous visual stimulation. It is suggested, therefore, that the critical variables affecting selective attention in this paradigm may be the perceptual relevance or meaningfulness of the extraneous stimulus and the relative timing of the response to it. An irrelevant stimulus which requires no response may be perceptually "filtered out"
at a level near the periphery and thereby produce no behavioral effect. A meaningful stimulus which requires a response, on the other hand, may produce an effect contingent upon the timing of the response. A response to the extraneous stimulation made prior to the onset of the target pattern may produce lateral facilitation while a response made after the pattern may result in lateral inhibition.

In order to empirically test these predictions, one should essentially replicate the present study with a split-plot design. The procedure of the present experiment would be replicated varying only the response conditions to the extraneous stimulus between groups. The first group would not be required to respond to the extraneous cue. The second group would respond before the onset of the target binary pattern. The final group would respond after they had responded to the target pattern. In order to minimize eye movements and the onset asynchrony of the priming stimulus and target stimulus, all Ss would respond to the extraneous stimulation by pressing a key with the hand which corresponded to the side of stimulation. Approaching this problem through a series of converging operations, as elaborated by Garner, Hake, and Eriksen (1956), may limit the number of alternative interpretations of the experimental results and provide straightforward support for variables critical to the operation of selective attention.
APPENDIXES
APPENDIX A

EIGHT ELEMENT BINARY PATTERNS

```
 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0
 0 0 0 0 0 0 0 0
```

50 .
APPENDIX B

ORDER OF PRESENTATION OF EXPERIMENTAL CONDITIONS

<table>
<thead>
<tr>
<th>Extraneous Stimulus (ES)</th>
<th>Order of Report (OR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Left</td>
</tr>
<tr>
<td>R</td>
<td>Right</td>
</tr>
<tr>
<td>B</td>
<td>Both</td>
</tr>
<tr>
<td>N</td>
<td>Neither</td>
</tr>
</tbody>
</table>

L Left to Right
R Right to Left

<table>
<thead>
<tr>
<th>Trial</th>
<th>ES</th>
<th>OR</th>
<th>Trial</th>
<th>ES</th>
<th>OR</th>
<th>Trial</th>
<th>ES</th>
<th>OR</th>
<th>Trial</th>
<th>ES</th>
<th>OR</th>
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<tr>
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<td>R</td>
<td>21</td>
<td>R</td>
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<td>B</td>
<td>L</td>
<td>22</td>
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<td>R</td>
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<td>L</td>
<td>R</td>
</tr>
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<td>3</td>
<td>N</td>
<td>L</td>
<td>23</td>
<td>N</td>
<td>L</td>
<td>43</td>
<td>N</td>
<td>L</td>
<td>63</td>
<td>R</td>
<td>R</td>
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<tr>
<td>4</td>
<td>B</td>
<td>R</td>
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VITA

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