functions were made by adjusting first- and second-degree polynomial equations to give lines of best fit to the data points, as represented in Fig 1 (Dixon, 1967). It was found that under light adaptation, the quadratic component accounted for 28% of the variance and the linear, 33%. Under dark adaptation the quadratic accounted for 1.8% of the variance and the linear, 98% of the variance. The results of the analysis of variance on the light-adaptation conditions considered together with the results of the test and curve fitting all indicate a strong nonmonotonic component to the light-adapted masking function.

EXPERIMENT II
To test the hypothesis that dark adaptation shifts the U minimum toward shorter \( \Delta t \) values, a \( \Delta t \) value of zero was included in Experiment II. The zero \( \Delta t \) value allowed an assessment of the maximum effect of luminance-saturation contrast-reduction on target detection. Three levels of target energy were employed to test the hypothesis that increases in target energy will reduce target report (Purcell, Stewart, & Dembcr, 1969). An artificial pupil was used to control pupil size under light and dark adaptation.

Method

Subjects
Five normal, paid Ss participated in Experiment II.

Apparatus and Procedure

Experiment I, with the following exceptions. A 3-mm-diam artificial pupil was used in the adaptation condition. The masking fielf luminance was 40 ft-L. The adaptation field in the light-adapted condition was 40 ft-L. In the dark-adaptation condition this field was not illuminated. Three levels of target field illumination were tested. These were 20, 40, and 60 ft-L. Values of \( \Delta t \) equal to 0, 20, 30, 35, 40, -70, and -110 msec were presented to each S in a different random order, with data gathered in two different blocks of 25 responses each. So were light or dark adapted for 10 min, and only one adaptation condition was run for each S during one session.

Results and Discussion

The repeated measures analysis of variance disclosed significant main effects of \( \Delta t \), \( F(6,24) = 7.4, p < .001 \), and target luminance, \( F(2,8) = 210.25, p < .001 \). The analysis also disclosed two-way interactions of \( \Delta t \) by Adaptation, \( F(24, 2) = 5.78, p < .01 \), \( \Delta t \) by Target Luminance, \( F(2,4,8) = 5.30, p < .001 \), and Adaptation by Target Luminance, \( F(2,14) = 26.68, p < .001 \). There was also a three-way interaction of \( \Delta t \) by Adaptation by Target Luminance, \( F(12,4) = 9.02, p < .001 \).

Again the characteristics of the masking functions were determined by fitting polynomial equations to the masking functions. Under light adaptation with 20, 40, and 60 ft-L targets, the quadratic component accounted for 54.47, 64.81%, and 54.76% of the total variance, respectively. By comparison, the linear component accounted for only 6.14%, 1.56%, and 3% of the total variance. Under dark adaptation with 20, 40, and 60 ft-L targets, the quadratic component accounted for 0.05%, 27.75%, and 54.8% of the total variance. The linear component accounted for 52.29%, 15.8%, and 8.84% of the total variance.

Adaptation state had several effects in Experiment II (see Fig 2). With the exception of the 20 ft-L-target condition, target detection was highest under light adaptation. Under light adaptation, target detection was also relatively constant, from the U minimum of -35 msec out to -70 msec. However, under dark adaptation, the U minimum was shifted to -20 msec, and target detection changed rapidly out to -70 msec. The U function are not predicted by present theories of metacommits (see Bridgeman, 1971; Weinstein, 1965).

Conclusion

Results of Experiment II provide evidence that disadaptation may reduce target detection. The findings, and the results of Cox & Dembcr (1973), contradict the speculation that U-shaped masking functions are not to be found when a found-choice detection task is employed (see Bridgeman, 1971; Eriksson, Becker & Hoffman, 1970; Kalman, 1968; Schirmer, 1972). Experiments I and II also indicate that light adaptation can, under certain circumstances, increase target detection. This finding is consistent with the argument that light adaptation can reduce the influence of luminance summation on masking (see Eriksson, 1966). It is also consistent with the idea that light adaptation reduced the mask's efficiency by reducing the magnitude of the neurologically "concealed" in the presence (see Boynton & Kandel, 1957). Both of these hypotheses are consistent with the idea that the mask may act together or are integrated in the visual system. As such, neither of them predicts U-shaped or masking functions. The possibility is rejected that temporal adaptation mechanisms may determine absolute levels of masking, but not necessarily the slope of the masking function.

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BULLETIN OF THE PSYCHOLOGICAL SOCIETY 1974, VOL. 3 (3A), 201-203

Detection of single letters and letters in words with changing vs unchanging mask characters

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With a forced-choice procedure and tachistoscopic displays, accuracy of identification was compared for letters presented alone vs the same letters embedded in words or in nonword letter strings. The advantage for single letters over letters embedded in words or nonwords was found to depend jointly upon characteristics of the pre- and postmarks and locations at the onset of single letter displays.

In contrast to the finding of Reicher (1969) and Wheeler (1970) that letters are better identified when embedded in words than when presented alone, several more recent studies (Bjork & Estes, 1973; Masaro, 1971; Thompson & Masaro, 1973) have reported a single letter advantage. All of these studies utilized tachistoscopic presentations with similar exposure durations, but there has been one principal difference in procedure. In the studies showing a word advantage, the target letters for a trial have been indicated to the S by means of a postexposure cue, whereas in the studies showing a single-letter advantage, the target letters have been known in advance and held constant over a block of trials. It has been suggested (Bjork & Estes, 1973; Masaro, 1973) that the latter procedure provides stricter control of effects of redundant information from word contexts at the decision level.

However, there are also differences between the two basic procedures which might operate at the perceptual level.
Design of Single Display Perceivers and Percentages of Correct Detections for All Conditions

<table>
<thead>
<tr>
<th>Group</th>
<th>SL Trial</th>
<th>Display Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sequence</td>
<td>Single Word</td>
</tr>
<tr>
<td>1</td>
<td>SLS</td>
<td>67</td>
</tr>
<tr>
<td>2</td>
<td>SLS</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>SL</td>
<td>95</td>
</tr>
<tr>
<td>4</td>
<td>SLS</td>
<td>57</td>
</tr>
</tbody>
</table>

Procedure

The SLs were informed about the general nature of the experiment but not about the perceptual tasks included. They received no information concerning correct detections or error rates. A trial began with a 2.4-c sec exposure of a row of mask characters followed by the SL, W, or NW display for 25 more, and then a row of mask characters which remained visible until the SL responded a key and terminated the trial. The post- and pre-mask characters occupied the same positions on the screen that were occupied by the letters of the display during the exposure itself. The displays always occupied four positions in a horizontal row centered on the screen.

Results

First, we need to check on the comparability of Groups 3 and 4, drawn from the Bjork and Estes (1973) study with the same pretreatments as the treatments of Groups 1 and 4 and Groups 2 and 3 were identical on WN and NW trials, the proportions of correct detections on the two types of trials (column 5). The interaction of Groups and SLS on these trials is needed in order to determine the generalization of the SL condition. (If the pre- and post-mask characters yield relatively weak patterns, and there is no change of characters from premask to postmask at the non-target positions in the SL displays.)

But within the SLS displays, one of these factors by itself is official. Thus, we find a SL advantage even when characters at non-target locations change at display onset, provided that the pre- and post-masks are not too effective (Group 2 of the present study) and even with high effective pre- and post-masks provided that there is no change in non-target locations at the display onset (Group 1 of the present study) when we use the SLS displays to determine the absence of a significant interaction of any effect of word context at the perceptual level when the task is defined as probe detection targeted letter.

References


Note: The single exception to what is one of the conditions of the Bjork and Estes (1973) study.)
Table 1
Design of Single- and Double-Target Detection Experiments

<table>
<thead>
<tr>
<th>Group</th>
<th>SL Trial Sequence</th>
<th>Display Type</th>
<th>Post-Target Detection Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$S$1 $S$3 $S$5</td>
<td>Single</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>$S$1 $S$2 $S$3</td>
<td>Single</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>$S$1 $S$2 $S$4</td>
<td>Single</td>
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</tr>
<tr>
<td>4</td>
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</tr>
<tr>
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<td>8</td>
<td>$S$1 $S$3 $S$5</td>
<td>Double</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>$S$2 $S$3 $S$5</td>
<td>Double</td>
<td>No</td>
</tr>
</tbody>
</table>

Note: Groups 3 and 4 from B & E, 1973.

level. For example, in the studies of Massaro (1973) and Thompson and Massaro (1973), the target letter was single on-SL trials and hence might have an advantage in terms of figure-ground contrast over letters embedded in words (W) or no words (NW) letter strings. In the study of Bjork and Estes (1973), this problem was bypassed in that the target letter on SL trials was always a row of node characters, either 5 or 8, which served also as pre- and postmarks. Their result was a substantial SL advantage with the longest # masks and no difference between SL and W trials with the more effective 5 masks. The suggested interpretation was that the more effective characters in the pre- and postmark display did not appear on the screen, all display positions sufficiently that lateral masking occurs primarily below the level of features and therefore yields no difference between SL and W trials at such a level.

But there is still a subtle confounding involving the SL vs W comparison in the Bjork and Estes study. Namely, between SL trials and postmarks, there was no change of characters at positions other than that of the target character from premask to display to postmask on SL trials, whereas the # signs also occurred at the non-target positions in all SL conditions. With # pre- and postmarks, however, there was a change at non-target postmark positions.

It appeared on the basis of other evidence in the study that this difference in the design of this aspect of the Bjork and Estes study produced a factorial comparison of effective change and ineffective or postmark characters with change vs no change at non-target positions on SL trials.

A subsidiary experiment in the present study checks on the effect of another procedural variable, the number of trials between preceding experiments by including a post-exposure cue for position of the target letter, a feature included in the studies of Reichle (1969) and Wheeler (1970), but not in those of Bjork and Estes, Massaro (1973), or Thompson and Massaro (1973).

**Method**

**Subjects and Apparatus.** The experiment was run with young adults with no previous experience in tachistoscopic studies who were paid for their services. The apparatus was the same as for the previous work (right-hand columns of Table 1), and the results were the same. The subjects were paid $1 per hour for the duration of the experiment. The instructions were the same as in the previous work (Table 1), and the right-hand columns of Table 1, provide the needed basis of comparison. It can be seen that the values obtained for Groups 3 and 4 under these conditions are closely recovered in Groups 4 and 2.

Turning then to the effects of the independent variables, it is immediately apparent that both type of mask character and change vs no change have substantial effects on performance under the SL condition. For each of the target letters in each of the two tasks, there is a higher percentage of correct detections for the no change condition and at each change condition there is a large advantage for the # over the 5 mask. The SL condition is superior to the other display types under all combinations of the two independent variables except the change condition with 5 mask, and there are no WA/NW differences under any conditions.

An analysis of variance of these detection data shows the main effect of type of mask character to be significant at the .01 level ($F = 22.9, df = 2/4, and F = 4.29, df = 1/12$, respectively), but the main effect of change vs no change is not significant. The interaction of change vs no change by display type is significant at the 1% level ($F = 6.0, df = 2/4$, and the interaction of mask character by display type yields $F = 2.38, df = 2/4$, where 3.40 is the requirement for significance at the 5% level. Utilizing the error term from the analysis of variance of the display type by mask character interaction, the standard error of the percentages for the postmask group is 3%. The SL advantage persists under the postmask condition, though possibly somewhat reduced, and again there is no WA/NW difference under any conditions.

**Results**

In agreement with nearly all previous experiments utilizing a detection procedure with target letters in advance, this study found a substantial superiority of single letter over letters embedded in words or no words, as predicted on the basis of the results of the previous work. In the subsidiary experiment, this effect was limited by signal-noise equivalence at the perceptual level (Estes, 1972) or at the lexical level (Estes, 1972) and a level of detection (Gill, 1972). The explanation of why this effect persists under the postmask condition, however, is not clear.

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