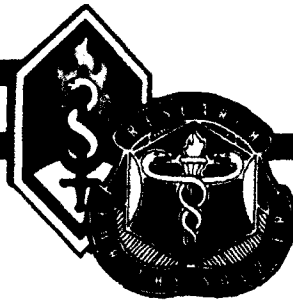


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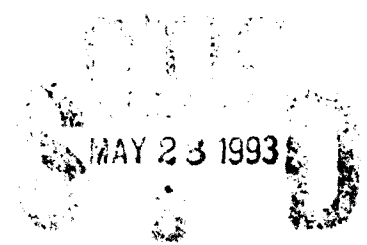


**Automaticity of Processing
Location versus Identity Information
in Brief Visual Displays**

by

**Robert L. Stephens
Jacquelyn Y. Pearson**

Biomedical Applications Research Division



March 1993

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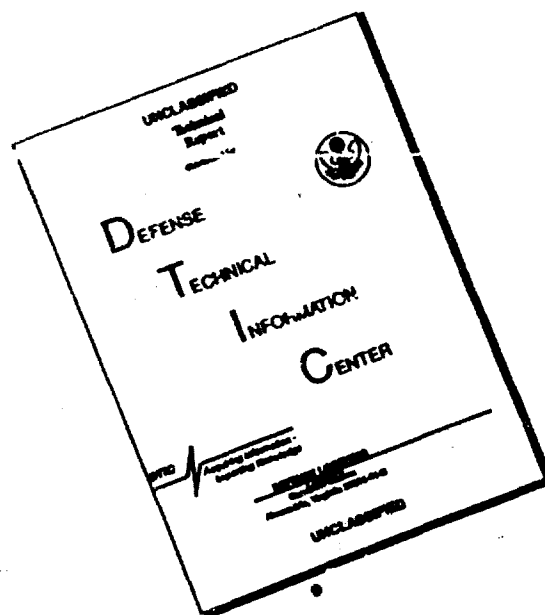


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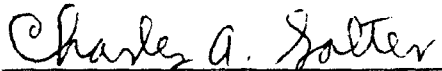
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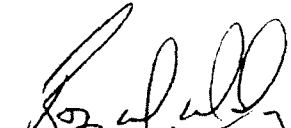
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Introduction

Shiffrin and Schneider (1977) advanced the notion that human information processing involves two distinct, but interrelated, modes: automatic and controlled processing. They defined automatic processes as being unaffected by practice, placing little demand on attention, being difficult to suppress once learned, and being virtually unaffected by processing load. Controlled processes, on the other hand, exhibit practice effects, place a large demand on attention, are relatively easy to alter, and are very dependent on processing load.

Hasher and Zacks (1979) incorporated this distinction into a set of criteria which must be satisfied before declaring that an attribute of the stimulus is automatically encoded. For a process to be automatic, it should be unaffected by intention, age, simultaneous processing demands, practice, or individual differences. They suggested that spatial location information processing is automatic.

Sagi and Julesz (1985) reported psychophysical evidence suggesting that localization appears to be automatic while identification appears to be a controlled process. Their subjects could detect and locate feature gradients in a complex stimulus in parallel. However, in order to identify the orientation of the features, they had to perform a serial inspection of the stimulus with focal attention.

Other research suggests the opposite. Butler (1980) found attention instructions differentially affected the occurrence of intrusion errors and mislocation errors in a selective masking task. Intrusion errors appeared to reflect an identification process which is relatively insensitive to attention instructions, suggesting identification is an automatic process. Mislocation errors appeared to reflect a localization process which is affected by attention instructions, suggesting localization is the principal limited-capacity operation.

Mason (1980) examined differences in highly skilled and less skilled readers' performances in a tachistoscopic task. She suggested location and identity information are processed independently. Highly skilled readers and less skilled readers were equally proficient at identifying letters which were presented in the central field-of-view. However, when the task was to name the serial position of a letter among nontarget items (an uppercase X superimposed on a dollar sign) highly skilled readers were significantly better than less skilled readers. Furthermore, when position of the target letter among the nontarget items was known, there was no difference in performance for the two groups. But when the target letter had to be located

first, the highly skilled readers again were significantly better than the less skilled readers. Thus, her results suggest that location information processing is a controlled process while identity information processing is automatic.

Naveh-Benjamin (1988) also failed to support the automaticity of spatial location information processing using a picture recognition task. In addition, Stephens and Runcie (1990) found individual differences in the ability to process location and identity information in a series of tachistoscopic tasks.

These inconsistencies in the determination of the level of automaticity of location and identity information processing appear to result from the definition of location and identity information within the various paradigms employed. The purpose of this investigation was to determine the differential levels of automaticity for processing location and identity information from tachistoscopically presented letter displays.

We hypothesized that acquisition of spatial location information in a tachistoscopically presented task would reflect controlled processing while acquisition of identity information would reflect automatic processing. To test this hypothesis, we used three variations of the partial report procedure (Averbach and Coriell, 1961) to examine: 1) the effects of processing location and identity information simultaneously and then independently on the accuracy of performance, and 2) the effects of practice on the ability to extract location and identity information.

Method

Subjects

Twelve male Army aviators were tested once a day for 4 days as training in preparation for a study of the effects of antihistamines on performance. Their ages ranged from 23 to 46 years (mean=32.42, s.d.=7.32). Six subjects performed the tasks at 1300 hours on each of 4 test days. The remaining six performed the tasks at 1500 hours. Subject participation was voluntary, and all subjects signed volunteer consent agreements.

Materials

Each test session involved the administration of three visual information processing tasks: a) a bar probe task, b) a letter identity task, and c) a letter location task. A Gerbrands 3-field tachistoscope (model 1483)* was used for stimulus presentation. The entire stimulus plane was 12.83° wide. Letter arrays consisted of eight randomly selected consonants (excluding Y). All letter stimuli were Helvetica 24 point black pressure-sensitive transfer letters on a white background. Bar probes were constructed using the letter I. Each array had an angular subtense of 5.53° horizontally and 0.41° vertically. Bar and letter probes were presented 0.30° above the letter array.

Procedure

Each task began with the presentation of 10 practice trials. Following practice, 64 test trials were presented. There were two trials at each array position for each of four interstimulus intervals. Each trial was preceded by a 500 ms presentation of a fixation cross located in the center of the stimulus field.

In the bar probe task, the fixation cross was followed by an array of 8 letters presented to the subject for 50 ms. Then a variable, dark interstimulus interval (ISI) of either 0-, 150-, 300-, or 450-ms duration was presented. Following the ISI, a bar probe appeared above one of the 8 positions of the array for 50 ms. The subject's task was to report correctly the letter which had appeared in the probed position. If he was unsure of the response, he was asked to guess. This task required the subject to extract letter location and identity information concurrently.

The letter identity task involved an array presentation identical to the bar probe task. Again, the array was followed by a variable, dark ISI. Following the ISI in this task, the subject was presented with a letter probe which appeared above the middle of the array. The subject's task was to decide whether or not the probe letter had appeared anywhere in the array. Presence or absence of the probe letter was random with the restriction that it was present on half of the trials and absent on the other half. In this task, the need to retain location information was minimized.

The letter location task was physically identical to the letter identity task. The subject was presented with the array,

* See appendix A

the variable dark ISI, and the letter probe above the middle of the array. In this task, however, the letter probe always was present in the array and the subject's task was to report the number of the position (1-8) the probe letter had occupied in the array. This task required subjects to extract spatial location information about the letters relative to the letter display while minimizing the need to retain identity information.

Results

A 4 x 3 x 4 repeated measures analysis of variance was performed with day, task, and ISI as factors. Reported p -values reflect corrections applied to the degrees of freedom where the sphericity assumption was violated. Results of this analysis revealed significant two-way interactions between day and ISI, $F(5.03, 55.31) = 2.55$, $p < 0.05$, and between day and task, $F(5.85, 64.40) = 2.37$, $p < 0.05$. In addition, the task x ISI interaction was marginally significant, $F(2.79, 30.66) = 2.55$, $p < 0.10$. Number of correct responses as a function of day and ISI for the three tasks is depicted in Figures 1-3.

Simple effects analysis for the day x task interaction revealed day simple effects on the bar probe task ($p < 0.0005$) and on the letter location task ($p < 0.005$). Contrasts for the day effect on the bar probe task indicated an increase in scores from day 1 to days 3 and 4. In addition, performance on day 4 was better than performance on day 2. Contrasts for the day effect on the letter location task indicated scores increased on days 3 and 4 compared to days 1 and 2.

Also, there were task simple effects for day 1 ($p < 0.0001$), day 2 ($p < 0.0001$), day 3 ($p < 0.0005$), and day 4 ($p < 0.05$). Contrasts for the task simple effects indicated letter identity task scores were higher than either bar probe or letter location task scores on each day.

The day x ISI interaction was accounted for by ISI simple effects on day 3 ($p < 0.05$) and day 4 ($p < 0.05$). Contrasts for the ISI simple effect on day 3 indicated a reduction in accuracy from 0 ms to 450 ms ISI, and from 300 ms to 450 ms ISI. Contrasts for the ISI simple effect on day 4 indicated lower performance at both 300 ms and 450 ms ISI compared to 150 ms ISI.

Further, there were day simple effects at 3 levels of ISI: 0 ms ($p < 0.0005$), 150 ms ($p < 0.005$), and 300 ms ($p < 0.001$). The contrasts for these effects revealed a significant increase in accuracy from day 1 to days 3 and 4 at 0 ms ISI. Accuracy increased significantly from day 1 to day 4 at 150 ms ISI, while

Bar probe task

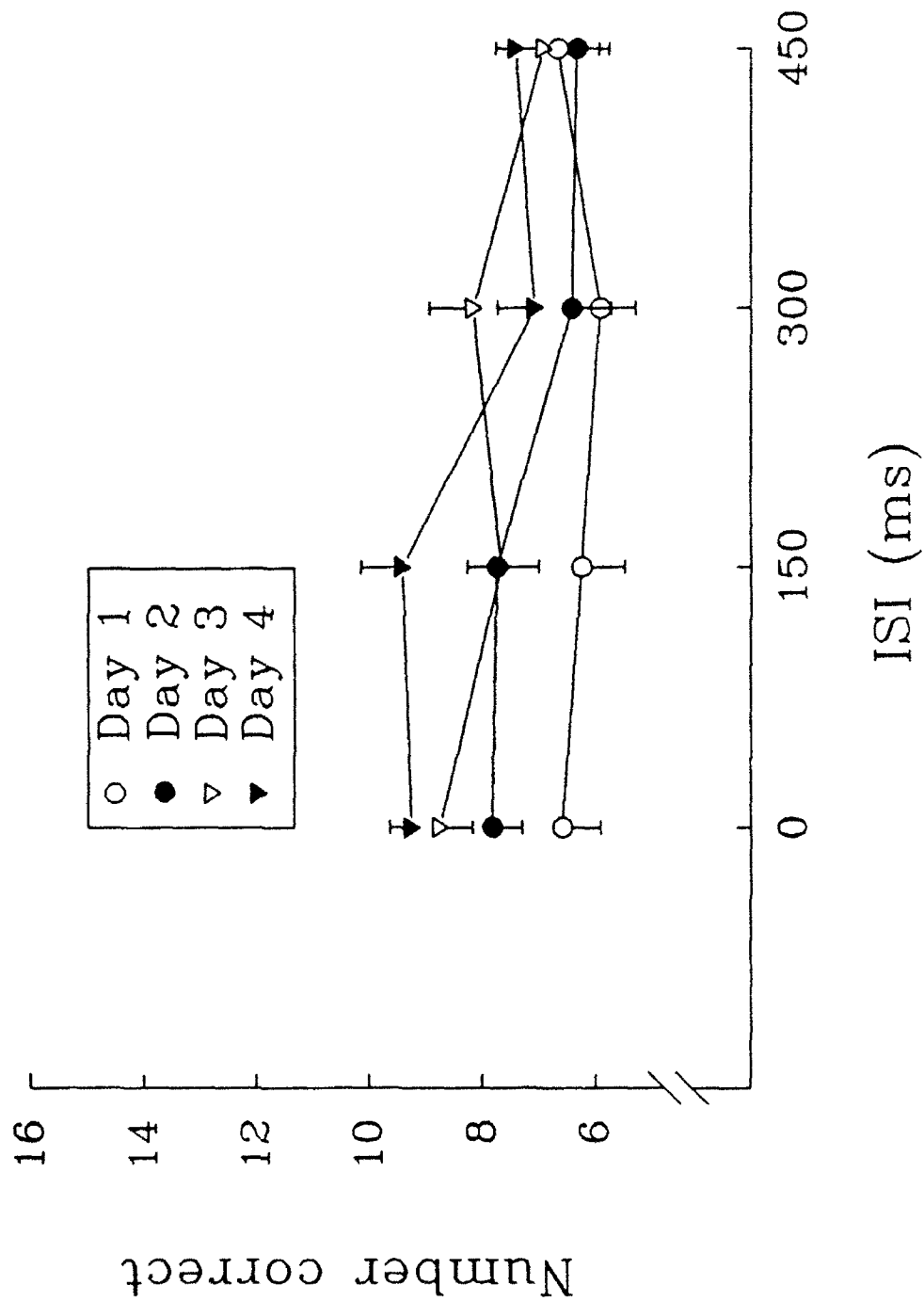


Figure 1. Number correct out of 16 as a function of day and interstimulus interval (ISI) for the bar probe task.

Letter identity task

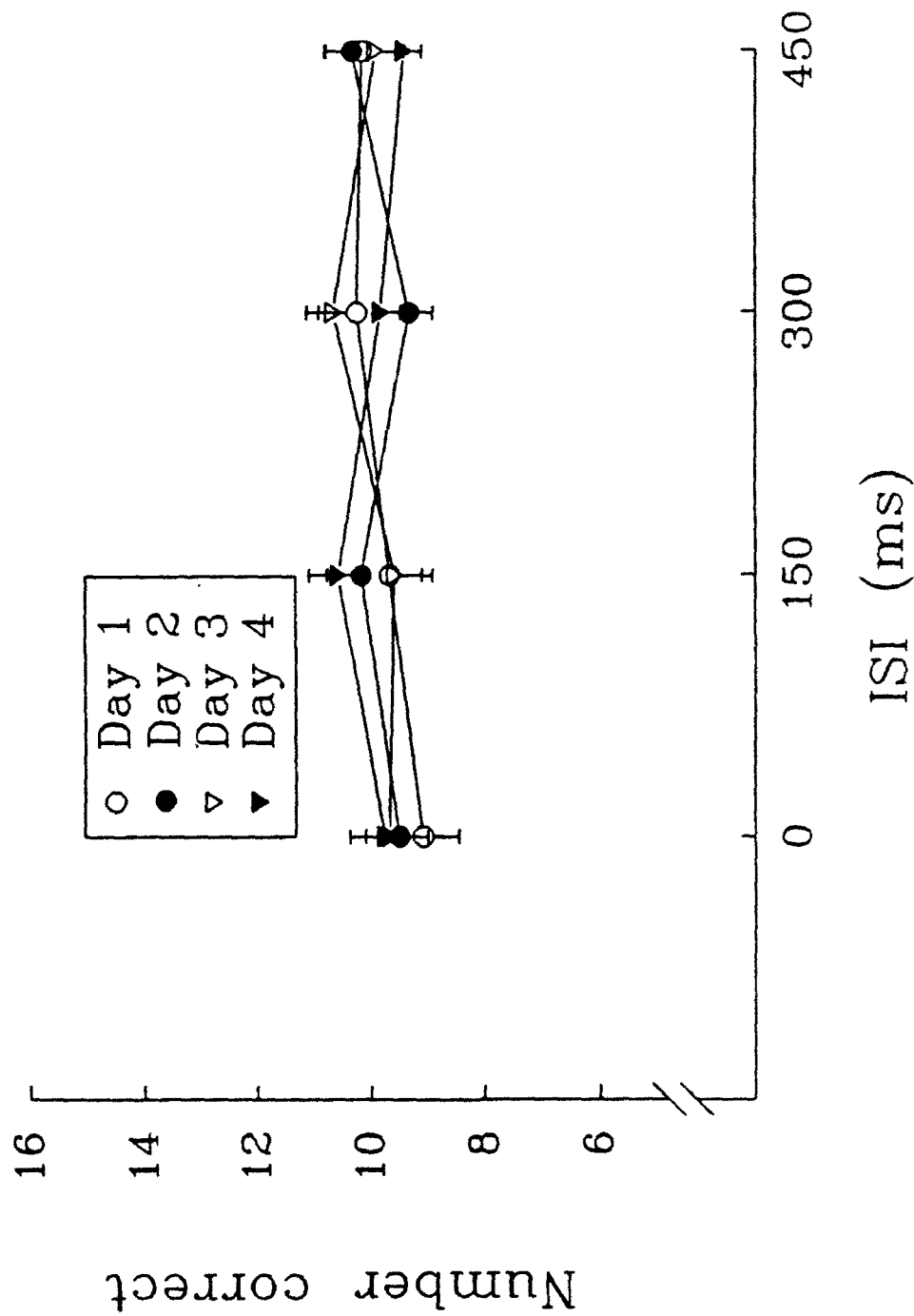


Figure 2. Number correct out of 16 as a function of day and interstimulus interval (ISI) for the letter identity task.

Letter location task

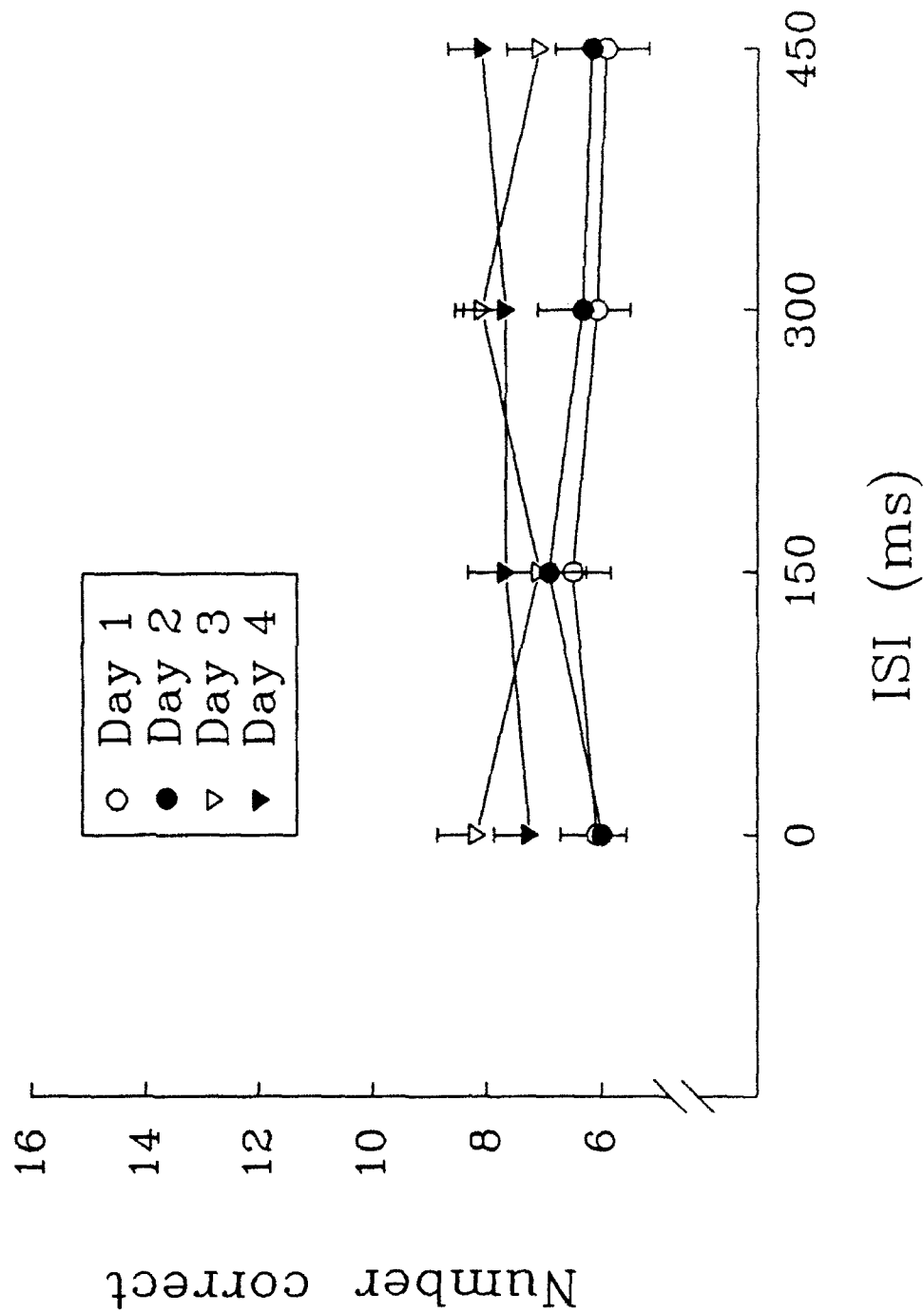


Figure 3. Number correct out of 16 as a function of day and interstimulus interval (ISI) for the letter location task.

only the increase from day 1 to day 3 was significant at 300 ms ISI.

Discussion

For the tasks employed in this experiment, automaticity occurs when localization or identification of a stimulus does not require conscious direction of attention to memory representations of letter features or their spatial relationships. Automaticity fails when one must consciously direct attention to letter feature or location information (c.f., Hasher and Zacks, 1979; Shiffrin and Schneider, 1977).

Evidence for automaticity of letter identification is provided by the lack of practice effects on the letter identity task. This likely results from the extensive experience normal adults have with letter feature acquisition during reading (Fisher and Montanary, 1977). Letter location appears to be a controlled process, as evidenced by the increase in accuracy of performance with practice on the letter location task. While concomitant experience in letter location information processing is gained with reading experience, the use of random consonant arrays in this study removed any facilitation such experience would provide by eliminating phonologically recognizable consonant-vowel combinations. Thus, whole-word processing is replaced with a lower-level, letter-by-letter process.

Both the letter location task and the bar probe task showed improvement in performance with practice, but practiced performance in the letter location task showed no loss of location information with increasing ISI, whereas performance in the bar probe task did. If processing of letter location information is becoming increasingly automatic, as indicated by improvement with practice, then either the process of acquisition of letter location information in the two tasks is different, or the requirement to process both types of information simultaneously impairs performance at the longer ISIs.

While both tasks elicit controlled processes initially, the available location information is used differently. In the bar probe task, the subject appears to rely on the provision of a location cue which directs attention to the important feature information. No such location cues are provided in the letter location task which forces subjects into more complete processing of feature information from the entire display prior to cue presentation. Cue processing in the letter location task may require feature extraction to the level necessary for a physical match, thus allowing a longer time for decay of feature information from the memory representation of the array. This

would account for the lower accuracy at the shorter ISIs in the letter location task relative to the bar probe task.

Phenomenologically, there seems to be a unitary quality to the perception of location and identity information in the visual system. However, the existence of differential levels of automaticity for identity and location information suggests that these two processes are independent. There is much evidence, both physiological and behavioral, to support this conclusion. Schneider (1969) reported evidence suggesting localization and pattern recognition in hamsters are mediated by different areas of the brain. DeYoe and Van Essen (1988) cited evidence for separate processing pathways in primate cortex, but argued that connections between parallel pathways could provide redundant representation of sensory cues in different anatomical areas. Behaviorally, many experiments with humans point to this same independence of identity and location information (Butler, 1980; Dick, 1969; Mason, 1980; Sagi and Julesz, 1985; and Townsend, 1973). This evidence, combined with the findings of the present investigation, suggests spatial and identity information must be processed by different areas of the visual system.

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Townsend, V. M. 1973. Loss of spatial and identity information following tachistoscopic exposure. Journal of experimental psychology. 98: 113-118.

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