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THE ROLE OF ATTENTION IN PROCESSING ORGANIZED AND UNORGANIZED MULTI-OBJECT DISPLAYS

BY

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

DOCTOR OF PHILOSOPHY

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The Role of Attention in Processing Organized and
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Abstract

Recent attention research indicates that attention must focused
narrowly on the location of a stimulus before that stimulus can be
identified. Focal attention has also been shown to play an important
role in the process of localizing and integrating the basic features of
stimuli. Although this suggests that little information is available
without focal attention, there is picture perception research which
suggests that important information is available by means of a global
process that is sensitive to the meaningful relationships that exist
among objects in scenes. In an attempt to reconcile this discrepancy,
attention was focused on a target object while the organization of the
surrounding background objects was varied. In Experiment 1, there was
general interference from the presence of background objects in the
visual field, but no indication that the identities or spatial
organization of those objects affected performance. In Experiments 2
and 3, the objects were moved closer together to form more coherent
displays. In these two experiments, there was evidence that both the
identities and the spatial organization of background objects affected
performance. The effects generally persisted even after attention was
focused on the target. The processing of unorganized background objects
was more affected by attentional manipulations than the processing of
organized background objects suggesting that information in organized
scenes is, at least in part, available by means of a process that is
independent of focal attention.
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The Role of Attention in Processing Organized and Unorganized Multi-Object Displays

Introduction

We have probably all had the experience of focusing attention on a particular object while at the same time ignoring other objects that may also be present. Even when attention is focused on a given object, however, unattended objects do not entirely disappear so some perception occurs whether attention is focused on an object or not. A distinction between a focused mode of perception and a "surrounding field of consciousness" goes back at least to Wundt (see Titchener, 1908) and perhaps further. Clarifying this distinction has been a major goal of attention research.

Modern attention research has its roots in the dichotic listening research of the early to mid 1950's (Cherry, 1953; Broadbent, 1958). Unlike much previous research which made use of subjective report, the dichotic listening research defined attention objectively and precisely in terms of the accuracy of response to a given individual stimulus. This approach required that individual stimuli be clearly defined and easily distinguished from one another. This emphasis on the individual nature of stimuli has led to relatively simple stimulus displays composed of small numbers of distinct and unrelated stimuli. Although much useful information has been obtained from these experiments, it is not clear to what extent these findings apply to complex stimulus situations typical of more naturalistic settings.
The real world is typified by large numbers of objects that vary widely in size and shape, and often overlap or occlude one another. What is more, objects often exist not only individually, but also in relationship to other objects. These factors are generally considered to be sources of unwanted noise in attention experiments and are either designed out of the experiment or are controlled for. However, the complexity of the real world environment forms the basis for much picture perception research (Biederman, 1981; Biederman, Mezzanotte & Rabinowitz, 1982). This research suggests that, rather than being a source of unwanted noise, complexity in the real world reflects an important source of information that is missing in the typical attention experiment. The present experiments were designed to investigate the possibility that certain characteristics of the real world, most notably the meaningful relationships that exist among individual objects, may affect performance in a paradigm that closely approximates the typical attention experiment.

Focal Attention and Perception: Evidence From Attention Research

It has been known for some time now that when a perceiver is presented with two or more simultaneous sources of stimulation, information can be selectively taken in from one source to at least the partial exclusion of other sources. Some of the earliest studies employed a dichotic listening task in which separate spoken messages were simultaneously presented to each ear and the subject was to repeat back or shadow one of the messages (e.g., Broadbent, 1958; Cherry, 1953). It was found that subjects could perform this task quite well
with essentially no interference from the nonshadowed message. Upon subsequent questioning, subjects showed very little knowledge of the nonshadowed message. For example, although they could detect such gross characteristics as a change from a male voice to a female voice, they were unable to detect that the unattended message was spoken in a foreign language. The view of perception that arose from these early studies postulated two distinct stages: an early parallel stage in which perceptual processing occurs simultaneously for all available stimuli, and a second selective stage which is associated with attention and restricted to one or perhaps a few of the available stimuli.

The selective processing of visual stimuli was demonstrated in the early 1960's when it was discovered that identification accuracy for a given letter in a briefly presented array of letters was enhanced if the spatial location of the letter was indicated by means of a cue (e.g., Averbach & Coriell, 1963; Sperling, 1963). The interpretation of this effect was that the location cue served to facilitate the process of focusing attention on an individual stimulus.

One of the more interesting findings in this early research was that a location cue was more effective (i.e., identification accuracy was higher) when it preceded the actual onset of the stimulus display than when it followed it. In other words, the process of selectively focusing attention on a given spatial location can begin even before a meaningful stimulus is available to be processed. Eriksen and Collins (1969) found that letter identification accuracy improved steadily as the interval between cue onset and stimulus onset (stimulus onset asynchrony or SOA) became longer. A point was reached, however, when temporally more advanced information was of no further benefit.
(approximately 150-200 ms). This shows that the process of focusing attention on a given spatial location has a definite time course. Location precues allow the focusing process to begin prior to stimulus onset such that there is a corresponding increase in processing efficiency. However, there is a point in time at which attention becomes maximally focused and asymptotic performance is reached.

Eriksen and Hoffman (1972a) were the first to use response latency (response time or RT) as the dependent measure in a location cuing task in which the stimulus display remained visible until a response was emitted. With RT as the dependent measure, it could be directly determined whether precuing the location of a stimulus actually affected the speed with which the stimulus was processed. The pattern of results was consistent with those previously obtained using brief exposures and identification accuracy as the dependent measure; RTs were faster when the cue preceded the display by 150 ms than when it occurred simultaneously with the onset of the display. Thus, the process of focusing attention is a time consuming component of the overall process of perceiving and responding to a stimulus.

What is the nature of this focusing process? A reasonable possibility is that attention is initially spread broadly across the visual field and then gradually becomes more narrowly focused on a given spatial location with time. Eriksen and Hoffman (1972b) investigated this possibility using stimulus displays in which the target and distractors were positioned along the circumference of an imaginary circle. The spacing of the nearest distractor was either .53 degrees, 1.0 degree, or 1.4 degrees visual angle from the target. The onset of the distractors was timed to occur from 0 to 300 ms after the onset of
the target and location cue. If attentional focusing reflects a gradual narrowing down process, then this process should begin with the onset of the target and location cue. With short SOAs, attention would still be focused broadly across the visual field and even distractors farthest from the target would fall within the focus of attention creating interference. With longer SOAs, attention would become more narrowly focused and these distractors would begin to fall outside the focus of attention while those closer to the target would still interfere. With even longer SOAs, these would also fall outside the focus of attention and cease to interfere. The predicted pattern of results, therefore, was that distractors would cease to interfere with target identification at progressively longer SOAs the closer the distractors were spaced to the target.

Performance became asymptotic at the same SOA for all three target spacings arguing against the hypothesis that the focus of attention contracts more and more with time. Interference in the preasymptotic portion of the SOA function was greatest at the .53 spacing, but was equal at each the 1.0 and 1.4 spacings. Eriksen and Hoffman (1972b) concluded that attention is a spatially localized region of processing activity with a minimum diameter of approximately one degree of visual angle. Distractors that fall within this minimum area are processed along with the target resulting in a loss of processing efficiency that is reflected in longer RTs. Stimuli that fall outside this minimum area do not compete for attentional resources, although there is still some interference that is independent of stimulus spacing. Eriksen and Hoffman suggested that stimuli within the focus of attention receive more detailed processing than those outside the focus of attention.
Several more recent investigations have provided evidence that attentional focusing reflects a process by which attention is reoriented from one location in visual space to another (e.g., Remington, 1980; Shulman, Remington & McLean, 1979; Tsal, 1983). Tsal (1983) conducted one of the more interesting studies in this area. A single target stimulus that was spaced either 4, 8 or 12 degrees visual angle to the left or right of fixation and the correct location of the target was precued across a range of SOAs. The task was to determine as quickly as possible which one of two letter stimuli was presented. At all three distances, RTs declined as a function of SOA until an asymptote was reached. Asymptotic performance, however, was reached at proportionally longer SOAs for each of the longer distances, indicating that attentional focusing is in some way linked to the distance of the target from fixation; the focusing process takes longer the farther the target is from fixation. Because asymptotic SOA values increased linearly with distance, Tsal (1983) concluded that attention moves at a constant velocity through visual space.

Although Remington and Pierce (1984) have provided evidence that attention can move in discontinuous jumps that are insensitive to distance, procedural differences may account for this discrepancy. Specifically, the target location in their experiment was cued by means of an arrow presented at fixation which pointed to the relevant location. The important point, however, is that attentional focusing reflects a process by which attention is reoriented from one location in visual space to another. At least in some cases, this process appears to involve a movement of attention through visual space. Location precuing allows attention to begin moving before stimulus onset such
that less total time is spent moving the remaining distance after the
target stimulus appears.

A second interesting finding in Tsal's (1983) study was that the
slopes of preasymptotic SOA functions consistently approached the value
of -1. In other words, reduction in RT was completely reflected in the
amount of time that the cue preceded onset of the target. This
indicates that performance was unaffected by any stimulus processing
that may have occurred while attention was moving. A similar pattern of
results has been obtained by Anderson (note 1, exps. 3 and 4). It
therefore appears that some component of the overall process of
perceiving and/or responding to a stimulus requires that attention first
be focused on the stimulus.

Anderson (note 1, exp. 3) employed a manipulation that was designed
to test directly the extent to which stimulus specific information may
affect performance before attention is focused on a stimulus. In one
condition (the partial cue condition), target location was precued
across a range of SOAs with a noninformative representation of the
target composed of features common to both target stimuli. In another
condition (the stimulus cue condition), target location was precued with
the complete target. The important question concerns possible
differences between conditions in preasymptotic portions of the SOA
function. Response times remained essentially equal across all levels
of SOA in the partial cue condition indicating that asymptotic
performance was reached at approximately 17 ms (the shortest SOA). At
this SOA, the complete target in the stimulus cue condition had been
visible for 17 ms. However, there was essentially no difference between
the partial cue condition and the stimulus cue condition at this SOA.
Complete stimulus information, therefore, was of no use for responding before attention was focused on the stimulus.

These results suggest that attention is much like a spotlight with a more or less clearly defined boundary. Very little information appears to be available from a stimulus that lies outside the attentional boundary. Visual perception, therefore, appears to involve two relatively independent modes or stages of processing. One operates in parallel across the visual field and serves as the basis for directing attention, but appears to yield very little in the way of stimulus specific information. The other (selective attention) is spatially localized, operates much like a scanning mechanism, and plays an important role in stimulus identification. Hoffman (1975) has argued for a very similar formulation based on the results of precuing experiments in which distractor stimuli where also present in the visual field.

Location precues affect performance even when a single stimulus is presented in an otherwise blank visual field (Anderson, note 1; Eriksen & Hoffman, 1974; Tsai, 1983). Thus, attention must play some positive role in the processing of stimuli apart from simply filtering out or excluding distracting information from active processing (as suggested, for example, by Treisman's, 1969 filter theory). It is tempting to conclude that attention must be involved in the earlier stages of perceptual processing. However, even though stimuli must be attended before they can identified, it is not clear that this necessarily implicates attention in the perception of stimuli. It is possible, for example, that stimuli are fully processed and identified without attention and that attention plays some post-perceptual role in
selecting inputs to a response mechanism or in scanning the contents of short term memory (Duncan, 1980; Shiffrin, 1975; Shiffrin & Schneider, 1977). Duncan (1981) has pointed out that because cuing affects only the process by which attention is directed to the location of a stimulus, cuing studies do not necessarily address the question of whether attention affects perception per se.

Anderson (note 1, exp. 4) addressed this question by masking the target stimulus at an exposure duration (33 ms) that was less than the asymptotic SOA value (50 ms). Thus, only the masking stimulus was visible when attention arrived at the stimulus location. Despite this fact, identification accuracy was 96% indicating that sufficient information survived the mask to allow for accurate discriminations. Although this clearly demonstrates that at least some useful information is available before a stimulus is attended, it is still not clear whether this information is the result of detailed perceptual analysis or simply reflects the presence of low level features or gross shape characteristics. The bulk of stimulus processing including detailed feature analysis and the extraction of higher level semantic information may, therefore, still require focal attention.

Tsai (1983, exp. 2) employed a stimulus difficulty manipulation that permits an inference regarding whether detailed perceptual processing occurs before or after attention is focused on a stimulus. In one condition, target letters were easy to discriminate (a C and an X) whereas in another condition target letters were difficult to discriminate (a D and an O). This difficulty manipulation had a large effect on performance in that RTs were approximately 100 ms longer for difficult stimuli than for easy stimuli. If it can be assumed that
difficulty affects perceptual processing, the important question concerns whether the effect of difficulty is localized before stimuli are attended or after attention is focused on a stimulus. If the effect of difficulty is localized after attention is focused on a stimulus, then it can be concluded that perceptual processing requires attention.

The locus of the effect of difficulty can be determined by the shape of the SOA function, in particular, the point at which asymptotic performance is reached. Imagine that with an SOA of 50 ms, attention arrives at the location of a stimulus just as early processing (i.e., unattended processing) completes. Longer SOAs (e.g., 150 ms) will provide no further benefit because although attention arrives at the location of the stimulus sooner, there is little or no information yet available to be processed by attention. Asymptotic performance, therefore, is reached at 50 ms. Now imagine that some manipulation (i.e., making the discrimination easier) speeds early processing by 100 ms. Because this information is available 100 ms sooner, attention can now arrive 100 ms sooner and begin processing the information rather than waiting for early processing to complete. In this case, asymptotic performance will be reached at an SOA of 150 ms rather than 50 ms.

Applying this logic to Tsal's experiment, if stimulus difficulty affects early processing, then asymptotic performance should be reached at an SOA that is 100 ms longer for easy stimuli than for difficult stimuli. Contrary to this prediction, asymptotic performance was reached at the same SOA in both the easy and difficult conditions. It therefore appears that the effect of stimulus difficulty is localized after attention is focused on a stimulus. The implication, of course,
is that perceptual processing also occurs after attention is focused on a stimulus.

There is a potential problem with this interpretation. Stimuli that are easy to discriminate can be identified at tachistoscopic exposures that are relatively brief (e.g., 33 ms for an O/Z discrimination with a post mask, Anderson, note 1, exp. 4). Thus, processing in this context would seem to proceed at a very rapid rate. It is hard to imagine that a variable such as stimulus difficulty would affect such a rapid process by as much as 100 ms (several orders of magnitude). Of course, the somewhat counterintuitive alternative is that stimulus difficulty does not affect perceptual processing, but rather, affects some other aspect of processing which occurs after a stimulus is attended. It is not obvious what processes other than perception would be affected by difficulty, however. In the end, studies that have manipulated characteristics of target stimuli remain somewhat inconclusive with respect to the question of how much stimuli are processed before and after they are attended.

There are a number of studies that have used indirect means to determine the extent to which stimuli are processed without attention. In these studies, attention is directed to a target stimulus while characteristics of distractor stimuli are manipulated. If stimuli are not extensively processed without attention, then only low level stimulus characteristics (e.g., object spacing or contour interference) would be expected to affect performance. If, on the other hand, stimuli are processed extensively without attention, then high level characteristics of distractors such as identity or meaning might be expected to affect performance as well.
Eriksen and his colleagues have performed a number of experiments using this basic paradigm. The stimuli were arranged in a circular configuration with the point of fixation located at the center of the circle. The location cue was a bar that appeared to the outside of the target stimulus. Results indicated that low level characteristics of distractors do affect performance. For example, as the number of distractors increases, RTs also increase (Colgate, Hoffman & Eriksen, 1973). Because the effect is as large in presymptotic portions of SOA functions as it is in asymptotic portions, increasing the number of distractors does not interfere with the process of focusing attention, but rather, some other aspect of stimulus identification.

In addition to these low level effects, a consistent finding is that RT also increases when distractors are associated with a response which is incompatible with that of the target (Eriksen & Hoffman, 1973; Eriksen & Schultz, 1979, Hoffman, 1975). Interference tends to be larger at shorter SOAs than at longer SOAs, suggesting that incompatible distractors have at least some effect on the process of focusing attention. Although interference is greatest when stimuli are spaced close together and incompatible distractors are immediately adjacent to the target, there is still evidence of interference when they are spaced two positions away with a compatible distractor in between. Evidence of interference (particularly for adjacent distractors) persists at SOAs all the way up to 350 ms, suggesting that incompatible distractors cannot be entirely focused out. It should be pointed out, however, that the stimuli in these experiments were centered approximately .50 degrees apart, so at least some of the effect may have been mediated by
inadvertent processing of distractors that fell within the minimal spotlight of attention.

Similar effects have been reported by other authors at much larger stimulus spacings. Gatti and Egeth (1978) used a variant of the Stroop task in which a color patch was presented at fixation and a color word was simultaneously presented at a spatially distant location. The time to name the color patch increased when the color word was incompatible with the color patch. Consistent with the results of Eriksen and Hoffman (1973), interference declined with increased spatial separation of the color word from the target, but was still evident at spatial separations of up to five degrees.

Underwood (1976) presented pictures of real world objects at a known spatial location to one side of fixation and presented a word on the opposite side of fixation. The stimuli were separated by approximately three degrees visual angle. The time to identify the picture was slower when the unattended word was related to the picture than when it was unrelated. This finding is interesting because the unattended word was not associated with a response.

Results such as these have been interpreted to indicate that stimuli are extensively processed without attention. The evidence for response interference suggests that the role of focal attention is primarily to select inputs to response mechanisms. Several authors (Broadbent, 1982; Kahneman & Treisman, 1984) have argued for an alternate interpretation. Specifically, when the response set is small and well defined such as in Eriksen's location cuing studies, subjects are primed to respond to relevant stimuli. Under such conditions, responses may be initiated by the presence of low level stimulus information (e.g., isolated features)
such that unattended stimuli need not be fully processed in order for them to affect performance. Interference of the type reported by Underwood (1976) can also be accommodated if one assumes that processing of the attended stimulus activates representations of related stimuli in semantic memory. A state of readiness would be created for these stimuli and they would obtain access to processing mechanisms shared by the target without having undergone detailed analysis.

There is evidence that when subjects are not in a state of readiness for stimuli, very little information is available until after attention is focused on a given stimulus. Kahneman, Treisman & Burkell (1983, exp. 1) had subjects identify a word target presented either alone or with a random dot patch of the same dimensions as the word. The logic of this experiment was that if stimuli are extensively processed without attention, then this information should be of use in guiding attention to the word target such that the presence of distractors should have no effect on performance. The time to name the word, however, increased when a random dot patch was presented on the opposite side of fixation, suggesting that attention could not be oriented directly to the location of the word target.

In another experiment (Kahneman, Treisman & Burkell, 1983, exp. 3), a word target was presented among strings of small geometric shapes that were of the same overall dimensions as the word targets. Response times increased as a linear function of the number of distractors. When target location was precued, however, number of distractors had essentially no effect on performance. The effect of precuing implies that the distractors interfered with performance because attention first had to be oriented to the location of a stimulus before it could be
determined that the stimulus was not a word. Even though distractors in both of these experiments could be distinguished from the word targets based on a very low level of analysis, it appears that stimuli are not sufficiently processed without attention for this information to serve as a basis for orienting attention. When the word target differed in color from the distractors and the task was simply to detect the presence of a word, there was no effect of the number of distractors. Thus, low level characteristics such as color do appear to be available without focal attention.

These results are consistent with a view of perception proposed by Treisman and her colleagues (Treisman & Gelade, 1980; Treisman, Sykes & Gelade, 1977). According to this view, basic features of stimuli (e.g., lines, angles, curves, colors, etc.) are perceived in parallel and without attention. However, attention must be directed to the spatial location of a stimulus before the separate features of that stimulus can be integrated to form a unitary object. The important characteristic of this view is that the presence of isolated features may in some cases be sufficient to mediate responding without attention, although a detailed analysis of the stimulus as a whole requires focal attention.

Treisman and Gelade (1980, exp. 4) provided evidence in the form of a visual search task in which the target letter could be distinguished from distractors on the basis of a single feature (e.g., an R among Ps and Bs), or on the basis of a conjunction of features that were each shared individually by the distractors (e.g., an R among Ps and Qs). In the feature condition, search times were a positive but negatively accelerated function of set size with the positive slope approximately one fourth the negative slope. The target in this case could,
therefore, be detected without directing attention to each individual stimulus location in turn. In the conjunction condition search times were a positive linear function of set size with the positive slope equal to one half the negative slope. Thus, when target identification requires that the features of stimuli be fully integrated, it appears that attention must be serially focused on each individual stimulus location before determining whether the target is present in that location.

Further evidence that focal attention to spatial location plays an important role in localizing and integrating features was provided in other experiments (Treisman and Gelade, 1980, exps. 8 and 9). Subjects were to determine which one of two possible targets appeared in a briefly presented array, and also to determine the target's spatial location. When the target could be distinguished from distractors on the basis of a single feature (either color or shape), report accuracy was above chance even when spatial location was incorrect by two or more positions. When the target could be distinguished from distractors only on the basis of a conjunction of features (color and shape), identification accuracy was at chance when spatial location was incorrect by two or more positions. Thus, feature targets can be detected without being precisely localized whereas conjunction targets cannot.

The link between focal attention, spatial location and the process of feature integration implies that location precues will be effective with conjunction targets, but not with feature targets. Treisman (1985) found that when targets were defined by a single feature such as color or shape, identification accuracy was essentially the same when the
correct location of the target was cued as when an incorrect location was cued. In contrast, when the target was defined by a conjunction of features, identification accuracy was significantly better when the correct location of the target was cued than when an incorrect location was cued.

Taken together, these studies indicate that isolated features are available without focal attention and may indeed be the source of interference obtained in the location cuing studies cited previously. Such effects, therefore, should not necessarily be taken as evidence that stimuli are extensively processed or analyzed without attention. When responding requires a fully integrated representation of the stimulus, it appears that attention must be directed to the spatial location of a stimulus before identification occurs. In this light, it is interesting to note Hoffman's (1975) finding that when distractors were not associated with a response, the effect on performance was the same whether they were familiar and nameable characters or character-like in shape but meaningless. Thus, there is little evidence that high level characteristics of unattended stimuli affect performance.

Targets in all of the location cuing studies cited previously could be discriminated on the basis of a single feature, yet evidence clearly indicates that these stimuli must nonetheless be attended before they can be identified. How does one reconcile this result with those of Treisman which show that feature targets may be identified without focal attention? Resolution of this discrepancy may lie in a distinction recently made between tasks for which the response may be determined by simple detection of the presence of a feature and tasks for which choice
of a response demands some further processing (Kahneman & Treisman, 1985; Treisman, Kahneman & Burkell, 1983). Speeded choice tasks may fall into this latter category even though on the surface, detection of a single feature would appear to be a sufficient basis for responding. Regardless of interpretation, the data clearly indicate that focal attention is required to perform the speeded-choice task.

To summarize, the research discussed thus far indicates that attention must be directed to the spatial location of a stimulus before the stimulus can be identified, except when responding may be based on detection of an isolated feature. Attention appears to play an important early role in the processing of stimuli, including localization and integration of basic stimulus features. Location precues are an effective means for directing attention to the location of a stimulus whether that stimulus is presented alone or among distractors. When attention is focused on a stimulus, effects from unattended distractor stimuli are limited primarily to low level characteristics such as spatial separation and/or number of distractors. The exception is when distractors are associated with an incompatible response or subjects are in a state of readiness to perceive unattended stimuli.

Evidence for Global Processing of Real World Scenes

The above research implies a sort of tunnel vision in that apart from isolated and spatially unlocalized features, very little information appears to be available from stimuli unless attention is first focused narrowly on individual stimulus objects. This seems at
odds with informal observations of real world perception which suggest that a great deal of information is available from the real world environment without attending to each and every object we encounter. Treisman (Treisman & Gelade, 1980; Treisman & Schmidt, 1982) suggests two possible ways to account for the apparent richness of real world perception. One is that features of objects in the real world may be conjoined at random without focal attention to yield meaningful objects. Laboratory research has demonstrated that this is possible (Treisman & Schmidt, 1982). A second possibility is that features may be conjoined in a top-down manner without focal attention based on context and/or experience. Again, there is laboratory research which demonstrates that when subjects are searching for a particular target, the features of spatially distant distractor stimuli may be combined incorrectly such that "illusory" targets are detected (Kleiss & Lane, 1986; Prinzmetal, 1981).

Although these possibilities are certainly feasible given the current state of attention research, they also imply that beyond the registration of isolated stimulus features, there may be little correspondence between what is phenomenally perceived and what may actually be present. This is particularly true with respect to the spatial locations of stimuli because if features are not localized without focal attention, then the objects they form are also not localized. Thus, Treisman concludes that "Perhaps this richness at the level of objects or scenes is largely an informed hallucination" (Treisman & Gelade, 1980, p. 133). Although this may well be true, the role of attention in perception has never been clearly addressed using stimuli that approximate the real world environment.
Eye movement research has revealed that subjects tend to fixate on the regions of a picture that are highest in information value (Yarbus, 1967). Although movements of attention may precede eye movements, the two have been shown to be functionally independent (Posner, 1980; Remington, 1980), so this research has little to say about the perceptual basis for either movements of attention or eye movements. Biederman and his colleagues (e.g., Biederman, 1972, 1981; Biederman, Mezzanotte & Rabinowitz, 1982) have consistently found that the overall context within which objects appear affects perception of those objects even at exposure durations of as little as 150 ms. This precludes changes in eye fixation and, presumably, limits the extent to which attention can be oriented from object to object as well. Although this would seem to indicate that a great deal of information is available very rapidly from scenic arrangements of objects, Treisman & Gelade (1980) have argued that the redundancy inherent in real world scenes yields a great deal of predictability regarding where objects are likely to be located and what those objects are likely to be. In other words, the redundancy in real world scenes facilitates attention allocation strategies and, therefore, the perception of objects in those scenes as well.

A prediction which follows from this line of reasoning is that if the location of an object in a real world scene is known in advance, there should be very little influence of contextual information on object perception. Beiderman (1972) performed an experiment the results of which argue against this interpretation. Subjects were presented with tachistoscopic exposures of real world photographs and the location of a single target object was cued 500 ms in advance of scene onset. In
one condition (coherent), the photograph was presented intact whereas in another condition (jumbled), the background surrounding the target was spatially rearranged. Jumbling was accomplished by cutting each photograph into six sections of roughly equal size and then spatially rearranging all but the section that contained the target object. The jumbling operation left most, but not all, of the background objects intact. The task was to select from among four possible alternatives the object that appeared in the cued location. Identification accuracy was significantly higher for objects in coherent photographs than for objects in jumbled photographs. Thus, perception was apparently influenced by context even when subjects knew where to look and, roughly, what to look for. What is more striking is that the primary manipulation was the spatial location of background information. Therefore, if we assume that the location precue was effective in focusing attention on the location of the target, it appears that some location information is available outside the focus of attention in real world scenes.

Some caution must be exercised in attributing the effect of jumbling to the efficiency of perception in organized real world scenes. Because there was no control condition in which target objects were presented alone, it may be that the effect of jumbling was due, at least in part, to inhibitory influences in the jumbled scenes. For example, because the jumbling operation created some object fragments, it may be that these fragments introduced a source of visual noise in the jumbled scenes that interfered with target identification by drawing attention away from the target. Biederman's (1972) argument against this possibility was that simply adding noise to coherent photographs by
scattering segments of other photographs on top of them did not appreciably reduce the ability to identify the scenes depicted in those photographs. Therefore, there is no strong reason to believe that the effect of jumbling was an artifact of the jumbling operation itself.

To the extent that the jumbling effect cannot be attributed solely to interference in the jumbled condition, it would appear that there is information available from unattended regions of coherent photographs that reflects the spatial organization of objects. This conclusion is at odds with attention research which links focal attention with both the processing of high level stimulus information and spatial location information. However, it must be noted once again that attention researchers have typically employed relatively simple stimulus situations which do not take into account the complex relationships that may exist among objects in the real world. It is possible that real world perception involves the processing of information that is simply not present in typical attention paradigms.

Support for this possibility comes from the work of Mandler and her colleagues (Mandler & Johnson, 1976; Mandler & Parker, 1976) who used a recognition memory task to investigate (among other things) the spatial information that is retained in organized (i.e., coherent) and unorganized (i.e., jumbled) arrangements of real world objects. Unlike Biederman's (1972) picture stimuli, Mandler's scenes were composed of nonoverlapping, hand drawn objects that could easily be rearranged without creating object fragments. Unorganized scenes were created by rotating each object in an organized scene 180 degrees and then turning the scene upside down to bring the objects back to their normal upright positions. In this way, the spacing of objects remained constant
between organized and unorganized scenes. Subjects were shown a sequence of scenes and then responded "same" or "different" to each of a sequence of test scenes. Half of the test scenes were identical to ones shown in the original sequence and half reflected subtle changes to the original scenes. Memory for spatial composition information -- that is, the absolute spatial locations of objects -- was better with unorganized scenes than with organized scenes. However, memory for spatial relation information -- that is, the locations of objects relative to other objects -- was better with organized scenes than with unorganized scenes.

Most attention research has employed displays of unrelated objects and the spatial location information typically of interest is absolute location. Evidence for a second kind of spatial location information in organized scenes (i.e., relative location) suggests that processing of scenes may indeed be different from processing displays of unrelated stimuli. Although no strong conclusions can be drawn from Mandler's results regarding possible effects of spatial relationships on perception, a reasonable assumption is that the jumbling effect in Beiderman's (1972) experiment was at least partially mediated by spatial relationships among objects in coherent scenes.

The idea that spatial relationships affect perception is not new even in attention research. Spatial relationships define stimulus grouping and grouping has been shown to affect the perception of individual objects in groups (see Pomerantz, 1981 for a review). However, there appear to be important differences between grouping effects and other forms of configural organization, and the organization in real world scenes. First, Biederman's (1972) study indicates that
scene organization facilitates perception whereas individual objects are perceived more poorly when they are grouped than when they are isolated from the group (Banks & Prinzmetal, 1976; Prinzmetal & Banks, 1977). In fact, Pomerantz (1981) defines configural organization as a failure of selective attention to individual stimuli.

A second reason to believe that scene organization is different from configural organization is that objects in organized scenes do not typically form any kind of recognizable spatial configuration. In fact, the absolute spatial configuration of objects in Mandler's scenes was identical between organized and unorganized scenes. One was simply the inverse of the other. The spatial relationships in organized scenes, therefore, depend not only on the relative positions of objects, but also on the identities of those objects as well. Because the very definition of a relationship implies the existence of two or more "things" (stimuli, objects, or whatever), scene perception would seem to involve some kind of global processing of information. This is contrasted with the role of focal attention which, according to most recent attention research, is geared towards the processing of individual objects.

Biederman, Rabinowitz, Glass and Stacy (1974) performed an experiment which provides evidence for two kinds of information in real world scenes. One is based on individual object identity and another is based on global characteristics of the scene as a whole. In experiment 1, coherent and jumbled real world scenes were presented at tachistoscopic exposure durations and the task was to select from a pair of scene descriptors made available prior to scene presentation the one that best matched the scene. In one condition, the descriptor pairs
were similar to one another (e.g., "shopping plaza" vs. "busy road and stores") whereas in another condition the descriptor pairs were
dissimilar (e.g., "shopping plaza" vs. "kitchen"). Because dissimilar
scenes shared few objects in common, a good strategy for choosing
between descriptors would be to identify one or a few objects. Because
similar scenes are likely to share many of the same objects, individual
object identification would be less diagnostic in selecting between
similar scene descriptors. Therefore, if there is a global form of
information available in organized scenes, similar descriptor pairs
should induce a global strategy. However, global information would also
be more disrupted by jumbling, so the effect of jumbling should be
larger with similar descriptors than with dissimilar descriptors.

As scene exposure durations increased from 20 ms to 300 ms, scene
identification accuracy also increased in each the coherent-dissimilar,
jumbled-dissimilar, and coherent-similar conditions. This order
reflects the order of accuracy from highest to lowest which maintained
across all levels of exposure duration. Scene identification accuracy
in the jumbled-similar condition was the lowest of the four conditions
and did not increase at all between 50 ms and 300 ms. At the 300 ms
exposure duration, the effect of jumbling was much larger for similar
descriptors than for dissimilar descriptors and this interaction was
statistically reliable. Accuracy in the coherent-dissimilar condition
was relatively high to begin with, however. The effect of jumbling may,
therefore, have been smaller for dissimilar descriptor pairs simply
because of a ceiling effect which limited the extent to which
performance could improve in the coherent-dissimilar condition.
In Experiment 2, the same coherent and jumbled scenes were presented across the same range of exposure durations, but the task was to identify a single object in each scene the location of which was cued after scene offset. For objects in coherent scenes, identification accuracy increased from exposure durations of 20 ms up to 100 ms, but increased no further between 100 ms and 300 ms. For objects in jumbled scenes, identification accuracy was lower than in coherent scenes at all exposure durations, but increased steadily all the way up to 300 ms. Thus, scene identification accuracy in the coherent/similar condition of Experiment 1 increased across a range of exposure durations that did not yield an increase in object identification accuracy for those same scenes in Experiment 2. In contrast, scene identification accuracy in the jumbled/similar condition of Experiment 1 did not increase across a range of exposure durations that did yield an increase in object identification accuracy for those same scenes in Experiment 2.

Biederman et al. (1974) concluded that there were two kinds of information available in real world scenes and therefore, two modes of processing information. One is geared for individual object identification whereas the other is holistic, based on the spatial relationships that exist among objects, and geared for global gist.

In subsequent research, Biederman (Biederman, 1981; Biederman, Mezzanotte & Rabinowitz, 1982) has found that relationships among objects in real world scenes extend beyond the relative spatial positions of objects per se and encompass higher level semantic constraints that exist between an individual object and its coherent background. These constraints include the object's probability in a given scene, its size relative to the background, and whether or not it
appears to be supported by a surface. When an object is violating one or more of these constraints, it is perceived both less accurately and more slowly than when it is in normal relationship to its background.

The common thread in this line of research is that there is information available in real world scenes that does not simply reflect the sum of individual objects in those scenes, but rather reflects some property of the objects taken together as a whole. The processing of this information appears to proceed independently of the processing of individual objects. In fact, the global information can actually affect the processing of individual objects.

Implications for Attention Paradigms

Views of perception that arise from attention research and picture perception research are similar in that they both postulate the existence of a spatially encompassing mode of processing and a mode of processing geared for individual object identification. The difference in these two lines of research lies in the emphasis placed on the spatially encompassing mode of processing. In attention research, the parallel stage is viewed as a precursor to individual object identification. It yields relatively low level stimulus information such as isolated features and/or gross configural properties of stimuli. In attention research, the major emphasis is on focal attention which appears to play a crucial role in processing individual stimuli including localization and integration of basic stimulus features.

Although the dependent measure in most picture perception research is the speed or accuracy of individual object identification, major
emphasis is on the global mode of processing. This processing is sensitive to the meaningful relationships that exist among objects, defined not only in terms of what the objects are (i.e., their identities), but also where they are located relative to one another. This processing, therefore, yields a high level form of information, and so, is rather sophisticated. This stands in marked contrast to current views of perception based on displays of unrelated letters, digits, words and/or abstract geometric shapes.

In light of the similarities and discrepancies between these two lines of research, an interesting question concerns the role of focal attention in perception of real world stimuli. One possibility is that organization in real world scenes induces a failure of selective attention such that attention expands to encompass at least a portion of the scene as a whole. This appears to be the case with configural organization, for example. However, failures of selective attention typically reduce the perceptibility of individual objects whereas scene organization appears to facilitate perception. The findings of Biederman, Rabinowitz, Glass and Stacy (1974) suggest that information regarding scene identity is available somewhat independently of individual object identity information. Because attention researchers (e.g., Kahneman & Treisman, 1984; Treisman, Kahneman & Burkell, 1983) have emphasized the role of attention in processing individual objects, it may be that the global information in scenes is independent of attention.

An approach to addressing this question would be to use a strong manipulation of focal attention in conjunction with real world type stimuli. Although Beideman (1972) used location precues in one
condition of his experiment and found evidence of an effect of scene organization, precues were always presented 500 ms in advance of scene onset. Because only one SOA was employed and because this SOA was extremely long by most attention standards, it is not really clear how the process of focusing attention proceeded in this context, or where attention was actually focused when the scene appeared. For example, attention may have initially been focused on the cued location, but wandered to other locations before the scene was presented. A more effective measure of focal attention would be to present location precues across a range of SOAs which are short enough to ensure capturing the focusing process itself.

Some consideration must also be given to the type of task employed in that not all perceptual tasks appear to require focal attention. Most notable are those for which the response may be determined by detection of the presence of a single distinguishing feature. Treisman (1985) has provided evidence that location precues are ineffective with tasks such as these. Stimuli typically used in attention research readily lend themselves to analysis in terms of features. However, it is not clear to what extent real world objects should be considered to be composed of a conjunction of features or definable in terms of a single feature alone. This issue is particularly relevant given that picture perception research typically employs identification and detection tasks which could potentially be performed by detecting single features. However, there is one task that consistently provides evidence of attentional focusing even when targets can be discriminated on the basis of single features. This task is the two-alternative, speeded choice task.
The use of a two-alternative, speeded-choice task with real world stimuli poses two problems not encountered with a more conventional detection task. The first relates to the location of the target. Because there must be locational uncertainty in a location cuing paradigm, the same target must appear in at least two locations. However, an object in a scene cannot be moved without also affecting the relationships that exist between the object and other objects in the scene. A possible solution to this problem would be to use mirror images of each scene. If the target object was spaced some distance from a central fixation point, then a mirror image of the scene would position the object in a different location while maintaining exactly the same spatial relationships among objects. Although it is not clear whether presenting mirror images of scenes would affect perception of those scenes or the individual objects in them, the scenes would be equally meaningful.

Because an identification task allows for many different targets to be used within an experimental session, the same target/background combination need not be repeated. With a two-alternative, speeded-choice task, however, two possible targets are each presented repeatedly over trials. Thus, each background must also be presented repeatedly. This poses a second problem by introducing the possibility of learning effects which might interact with or moderate the crucial scene variables as subjects become more familiar with each scene. Biederman, Teitelbaum and Mezzanotte (1983) investigated the effects of both prior expectancies regarding what scene would be presented on a given trial and familiarity as a given scene was repeated five times within an experiment. Although RTs declined with increased familiarity,
neither expectancy nor familiarity interacted with any of the crucial scene variables. These variables reflected the extent to which the target violated such relationships as probability, size or support. Within the range of this experiment, therefore, repeating a given scene does not appear to qualitatively affect the manner in which the scene is perceived.

With a two-alternative, speeded-choice task, the scenes would be repeated many more than five times. To determine whether this increased level of exposure qualitatively affects the perception of scenes, trials could be blocked such that all combinations of the background and SOA variables would be repeated in consecutive blocks. Any effect of repeated exposure to scenes would therefore be revealed in an interaction with the block variable. Also, to determine whether or not general learning effects interact with the background variables, a different set of stimuli could be used in the second half of the experiment. Specific learning effects would disappear when stimuli were switched whereas general learning effects would transfer to the second half.

Experiment 1

Method

Design. There were four target objects with corresponding organized and unorganized backgrounds. Two target/background combinations represented outdoor scenes and two represented indoor scenes. The two outdoor targets and the two indoor targets were never paired with one another. Thus, there were four possible unique target
pairings. Sessions were divided into two halves with each half employing different target stimuli and corresponding backgrounds. The four possible target pairs could be combined in two ways to yield unique pairings across session halves (farmer/glass and deer/lamp, or farmer/lamp and deer/glass). These two combinations, the half that each pair in the combination appeared in (first or second), and the response button assigned to each target in the pair (right or left) were counterbalanced across subjects.

Each target appeared among the organized and unorganized background objects that were appropriate for it, and among the organized and unorganized background objects that were appropriate for the other target. As a control condition, each target also appeared alone. Location precues were presented across a range of five SOAs (17ms, 50ms, 83ms, 117ms, and 150ms). Each session half was composed of four blocks of 100 trials each. The 100 trials reflected the 100 possible combinations of five levels of background, five levels of SOA, and two possible target locations (left or right) for each of the two targets. The level of each of these variables was determined randomly on each trial.

Subjects. The subjects were 16 Rice University undergraduates (six female) who participated for course credit.

Apparatus and stimuli. Stimulus events were controlled and timed by an Apple Macintosh micro computer. The display was a black-on-white cathode ray tube (CRT) with a resolution of 74 dots per inch and a refresh rate of 1/60th of a second (16.67 ms). All stimulus exposure durations and inter-stimulus intervals were, therefore, in multiples of 60ths of a second. Response times were also measured in multiples of
60ths of a second. Lincoln and Lane (1980) have shown that the error introduced by this method does not appreciably affect the final results. The computer was situated on a table top within a small partitioned enclosure with fluorescent overhead lighting.

A cross measuring .48 degrees visual angle was centered on the display and served as a fixation point. A horizontal bar measuring .11 degrees by .44 degrees served as a location cue and was located with its near end 5.19 degrees horizontally from fixation.

The four scenes were a farm scene with a farmer target, an outdoor scene with a deer target, a living room scene with a lamp target, and a tabletop scene with a wine glass target. Scenes were constructed by placing seven line drawings of real world objects (including the target object) within the boundaries of a rectangular frame 8.50 degrees visual angle high by 11 degrees wide such that one object touched each of the four sides of the frame. Although these overall dimensions are somewhat smaller than the scenes typically used in picture perception research (e.g., 14 degrees wide by 11 degrees high, Biederman, Mezzanotte & Rabinowitz, 1982), the relatively small size of the objects allowed each object to be centered more than one degree from its nearest neighbor.

All target objects measured 2.00 degrees high by .38 degrees wide and were centered 4.31 degrees horizontally from fixation. Target objects were symmetrical about the vertical axis. The largest background object was a sofa in the living room scene which measured 1.75 degrees high by 3.37 degrees wide, and the smallest background object was a flock of birds in the outdoor scene which measured .88 degrees high by 1.25 degrees wide. Organized scenes each contained a horizon line which was located 1.75 degrees above the center of the
scene and spanned the width of the scene. After the objects were positioned within the frame, the frame was erased.

The objects in organized scenes were positioned such that meaningful relationships were represented including depth perspective. Following Mandler and Johnson (1976), unorganized versions of each scene were created by rotating each individual object in the organized scenes 180 degrees and then rotating the entire scene 180 degrees to bring the objects back to their normal upright positions. The horizon line was eliminated from unorganized scenes. With this method the center-to-center spacing of objects was identical between organized and unorganized scenes. The unorganized scenes, however, did not contain the meaningful spatial relationships present in the organized scenes. Because the target objects were located along the horizontal axis of the scene, the absolute spatial locations of the target objects were identical between organized and unorganized scenes. Examples of organized and unorganized versions of each scene are shown in Appendix A.

Each of the targets in the outdoor and farm scenes (both organized and unorganized versions) was exchanged with each target in the living room and tabletop scenes to create stimuli for the inappropriate background conditions. A mirror image of each of the above stimulus displays was also constructed. Because the targets were symmetrical about the vertical axis, the appearance of the target was unaffected by this manipulation.

Procedure. Subjects were tested individually in a single session lasting slightly less than one hour. At the beginning of each half the subject was shown the two target objects that would be used during that
half and was instructed as to which of two response buttons each target was assigned to. It was explained that on each trial, one of the two targets would appear briefly in one of the two possible locations and the task was simply to identify which of the targets had been presented by pushing the corresponding response button as quickly as possible. It was then explained that the correct location of the target would be cued in advance of stimulus onset. Although speed of response was stressed, subjects were encouraged to be as accurate as possible.

After affirming they understood the basic task, subjects were then informed that other objects would also be presented along with the target on most, but not all, trials. Subjects were shown examples of organized and unorganized versions of each scene including the appropriate target objects, and were told that the targets would appear not only among their own background objects, but also among the background objects for the other target as well. It was stressed that because background objects did not in any way provide information regarding the identity of the target, and because background objects did not have to be identified or remembered in any way, they could essentially be ignored. Lastly, subjects were told that when the target appeared on the opposite side of the display than that shown in the examples, a mirror image of the scene would be presented.

The sequence of events on each trial was as follows: the fixation cross appeared at the center of the display and, after 500 ms, was joined by the location cue which remained visible for 17 ms. After the appropriate SOA interval, which was measured from the onset of the location cue, the fixation cross was replaced by the stimulus display which remained visible for 100 ms. Thus, the total period of time
between onset of the location cue and offset of the stimulus display was, at most, 250 ms. This duration should have precluded any effects due to eye movements (Eriksen & Hoffman, 1972b).

Responses were entered by pushing either the "z" key on the computer keyboard with the left hand or the "/" key with the right hand. If a correct response was entered, the next trial began almost immediately. If an incorrect response was entered, an error message appeared on the screen and remained visible for approximately 2 s. The error message also appeared if the subject failed to respond within 3 s from the offset of the stimulus display. Subjects were given a break after each block of 100 trials at which time feedback was provided regarding number of errors in the previous block. Subjects began the next block of trials by pushing the space bar on the computer keyboard. Prior to beginning the second half, subjects were shown the new stimuli to be employed in that half and were told that all other procedural details were identical to the first half.

Results and discussion

All trials on which RTs were less than 200 ms were considered anticipatory errors and were deleted from the data set. All trials on which RTs were greater than 2000 ms were considered misses and were also deleted from the data set. The first block of trials in each half was considered practice and did not figure in the results. The median correct RT was calculated for each subject in each level of the Half, Block, SOA, and Background variables. Figure 1 shows the means of these medians for the five background conditions as a function of SOA. The means collapsed across SOA are shown at the far right and a line
Figure 1. Mean response time for each background condition in Experiment 1 as a function of SOA.
representing a slope of -1 is shown below the single target data between SOAs of 17 ms and 50 ms.

Mean RT is shortest for the single target condition and does not appear to differ appreciably among the four conditions that employed background objects. A clear difference is evident between the single target condition and the other four conditions across the three shortest SOAs, but RTs appear to converge at the longer SOAs and become essentially equal by 150 ms. There is a general tendency for RT's to decline as SOA increases with the rate of decline sharpest between SOAs of 17 ms and 50 ms. RT continues to decline sharply in the single target condition between SOAs of 50 ms and 83 ms after which asymptotic performance appears to have been reached. RTs in the remaining four conditions show no strong indication of asymptotic performance although RT in the organized/appropriate condition drops sharply between SOAs of 83 ms and 117 ms and then remains flat.

Figure 2 shows the mean RTs for the five background conditions as a function trial block and session half. There is a general reduction in RTs that occurs with repeated exposure to the stimuli. There is also a tendency in the first half of the session for the difference between the organized/appropriate and the organized/inappropriate conditions to become larger as a function of Trial block.

The data were submitted to a four-way, repeated-measures analysis of variance (ANOVA) with Background, SOA, Half and Block serving as within subjects factors. Mean RT differed reliably among the five background conditions, \( F(4,60) = 6.86, p < .001 \). Mean RT also differed reliably among the five levels of SOA, \( F(4,60) = 40.48, p < .001 \). The Background by SOA interaction approached statistical reliability,
Experiment 1

![Graph showing mean response time for each background condition in Experiment 1 as a function of Session half and Trial block.]

Figure 2. Mean response time for each background condition in Experiment 1 as a function of Session half and Trial block.
\( F(16,240) = 1.62, \ p = .065 \). The Background by SOA interaction was also tested using only the linear component of the SOA variable. This interaction was also not reliable, \( F(4,60) = 1.53, \ p = .206 \). None of the interactions involving Trial block, Session half and Background proved to be reliable. For the Session half by Background, and the Trial block by Background interactions, both \( F\text{S} < 1 \). For the Session half by Trial block by Background interaction, \( F(8,120) = 1.18, \ p = .317 \).

A series of \( t \) tests was performed on differences between consecutive SOAs in each of the five Background conditions. For the single target condition, RT declined reliably between SOAs of 17 ms and 50 ms, \( t(15) = 3.67, \ p < .01 \), and between SOAs of 50 ms and 83 ms, \( t(15) = 2.63, \ p = .019 \). For the organized/appropriate condition, RT declined reliably between SOAs of 17 ms and 50 ms, \( t(15) = 2.63, \ p = .019 \), and between SOA's of 83 ms and 117 ms, \( t(15) = 3.50, \ p < .01 \).

For the unorganized/appropriate condition, RT declined reliably only between SOAs of 50 ms and 83 ms, \( t(15) = 2.60, \ p = .020 \). For the organized/inappropriate condition, RT declined reliably only between SOAs of 17 ms and 50 ms, \( t(15) = 4.14, \ p < .001 \). For the unorganized/inappropriate condition, RT declined reliably only between SOAs of 17 ms and 50 ms, \( t(15) = 3.09, \ p < .01 \).

Error rates were calculated and submitted to a two-way, repeated-measures ANOVA with Background and SOA serving as within subject factors. Error rates differed reliably among the five background conditions, \( F(4,60) = 4.01, \ p < .01 \). Mean error rate was lowest in the single target condition (.031) and highest in the organized/inappropriate condition (.052). Error rates did not differ
among the levels of SOA, \( F < 1 \). The Background by SOA interaction was also not reliable, \( F(16, 240) = 1.26, p = .224 \). Thus, there is no evidence that the shorter RTs in the single target condition reflect a speed/accuracy trade off, or that accuracy changes as a function of SOA.

The fact that RTs decline sharply between SOAs of 17 ms and 50 ms with slopes approaching the value of \(-1\) indicates that the initial focusing process can be reasonably conceived as one involving attentional movement. The fact that mean RT in the unorganized/appropriate condition did not decline reliably across this range of SOAs is probably due to the fact that RT in this condition was unusually slow at SOA of 50 ms. At 50 ms, RT in this condition was the slowest of any of the conditions, and declined reliably by 83 ms to come more in line with the other conditions. Response time in the single target condition continues to decline sharply between SOAs of 50 ms and 83 ms and then becomes asymptotic. Performance in this condition replicates fairly nicely the results of Anderson (note 1) and Tsal (1983) and suggests that processes which underlie identification of real world objects are similar to those which underlie identification of letter stimuli.

If 83 ms is taken as an estimate of the amount of time it takes attention to move to the location of the target in the present experiment, then the fact that there is no strong tendency for RTs to decline sharply between SOAs of 50 ms and 83 ms when background objects are present suggests that background objects may interfere with attentional focusing if the background objects appear just as attention arrives at the target location.
There is no indication that performance varies among the four conditions that employed background objects. The reliable main effect of background can almost certainly be attributed to the faster mean RT in the single target condition compared to the other four conditions. The equivalence of the various backgrounds cannot be attributed to a learning process that may have reduced their effectiveness with repeated exposure. Thus, the primary effect of having background objects present in the display appears to be some low level form of interference that is based neither on the their identities nor on their spatial organization.

The source of this interference is not clear. The spacing of objects should have precluded contour interactions (Flom, Weymouth & Kahneman, 1963) as well as inadvertent processing of distractors that fall within the minimal spotlight of attention (Eriksen & Hoffman, 1972b). Colgate, Hoffman and Eriksen (1973) found that RT in a letter identification task that employed location precues increased as the number of distractors increased. Although the present effect of background objects may be interpreted as a display size effect, the stimuli in the Colgate et al. study were spaced much closer together than in the present study. In fact, the stimuli in the largest displays were centered .53 degrees apart so the display size effect may have been confounded by a failure of selectivity.

With spacings of greater than one degree, Kahneman, Treisman and Burkell (1983, exp. 4) found no difference among displays containing one, two, three or four stimuli when the target's location was precued 33 ms in advance of stimulus onset. In this light, it is interesting to note that the interfering effect of background objects appears to be less evident at the longest SOAs when attention is, presumably, most
focused. However, the nonreliable Background by SOA(L) interaction indicates that this tendency is not a particularly strong one.

These data suggest that there may be two or more phases in the process of focusing attention. There is an initial phase which involves attentional movement and is relatively unaffected by the presence of background objects. There may also be a later stage of focusing which occurs after attention has localized the target and which is effective in reducing interference from background objects. This last point must be considered tentative in that it is not supported statistically.

Experiment 2

The failure to find differences among the four conditions that employed background objects suggests that very little information is available from organized displays without focal attention. This is consistent with recent attention research, and supports the view that attention plays a very important role in perception whether stimuli are displays of unrelated letters, etc., or meaningful arrangements of real world objects. However, it may also be the case that the arrangements of objects in Experiment 1 were simply lacking in some critical component of real world organization. One potentially important difference between the stimuli employed in Experiment 1 and those in Mandler's scenes, for example (which were also composed of nonoverlapping objects, but did provide evidence of an effect of organization), is that the objects in Mandler's scenes were spaced more closely together. An obvious question, therefore, is whether the
spacing of objects in Experiment 1 was such that potential global characteristics were eliminated.

Kinchla and Wolf (1979) investigated the processing of global and local characteristics of displays of letters that were arranged to form a larger letter. These displays were viewed at various distances such that the overall size of the display in terms of degrees of visual angle covered a range of values. The extent to which local display elements (i.e., individual letters) and global display elements (i.e., the overall configuration) were processed most efficiently was dependent on the size of the configuration. With large displays (i.e., short viewing distances), local elements were processed fastest whereas with small displays (i.e., long viewing distances), global elements were processed fastest. These results argue that factors such as the absolute spacing of objects and the overall size of the display can play an important role in determining whether global display characteristics are processed.

To determine whether object spacing affects the processing of global characteristics of scenes, objects in the stimulus displays used in Experiment 1 were moved closer together. This resulted in scenes that appeared spatially more coherent. Although the edge-to-edge spacing of objects was smaller, the center-to-center spacing was still greater than one degree. Thus, to the extent that attention was focused on the target object, inadvertent processing of nearby objects should still have been minimized. Because the targets were closer to fixation in these new stimulus displays, attentional movements would be expected to take less time as well. Therefore, a range of shorter SOAs was employed which included smaller increments between consecutive SOAs.
Method

Design. The basic design was essentially the same as in Experiment 1. In order to provide a fully balanced design, however, each target was paired with each of the other three targets. The six possible target pairs could be combined in three ways to yield unique pairs across session halves (farmer/glass and deer/lamp, farmer/lamp and deer/glass, or farmer/deer and glass/lamp). These three combinations, the half that each pair appeared in and the response button assigned to each target were counterbalanced across subjects.

Subjects. The subjects were 24 Rice University graduate and undergraduate students (14 female). The graduate students were members of the Psychology department and volunteered their services. The undergraduates either received course credit or were paid for their services.

Apparatus and stimuli. The experiment was conducted on the same Apple Macintosh micro computer used in Experiment 1.

A cross measuring .48 degrees visual angle was centered on the display and served as a fixation point. A horizontal bar measuring .33 degrees by .11 degrees served as the location cue and was located with its near end 3.70 degrees horizontally from fixation.

Scenes were constructed in a manner similar to that described in Experiment 1. The rectangular frame, however, was smaller measuring 5.25 degrees visual angle in height by 7.69 degrees in width. The objects used to construct the new scenes were essentially the same as those used in Experiment 1. Some objects, however, proved to be too large to fit within the confines of the smaller frame without overlapping other objects and these were replaced. For example, the
rocking chair in the living room scene was replaced by a boy lying on the floor watching the television set, and the napkin/silverware in the tabletop scene was replaced by a small bowl. In addition, some objects were altered slightly to improve detail or to compensate for changes in depth perspective that occurred when the objects were moved closer together. Lastly, the relative positions of some objects were changed both to improve the coherency of organized scenes and to insure that objects did not overlap after they were rotated to form unorganized scenes.

The target objects remained unchanged from Experiment 1 and were centered 2.81 degrees horizontally from fixation. The largest nontarget object was still the sofa in the living room scene and the smallest nontarget object was still the flock of birds in the outdoor scene. With these changes, each object in the scene (including the target) was spaced less than one degree edge-to-edge from its nearest neighbor. However, the center-to-center spacing of objects (including targets) was still greater than one degree. Thus, if Eriksen and Spencer's (1972b) suggestion that attention has a minimum area of focus of one degree is true, inadvertent processing of background objects should still be minimized once attention is focused on the target location.

Inappropriate target/background relationships were obtained by exchanging each target in the organized and unorganized backgrounds with each of the other three targets. Lastly, mirror images of each scene were also constructed.

**Procedure.** The procedure was identical to Experiment 1.

**Results**
After the data were collected, it was discovered that one of the stimulus displays had been consistently presented backwards to four of the subjects. Specifically, when the left target location was cued and the wine glass was to appear among the unorganized farm objects, the target actually appeared on the right side. The data from these trials were therefore deleted from the raw data set. Interestingly, only one subject commented on this problem.

As in Experiment 1, RTs less than 200 ms and greater than 2000 ms were considered errors and were deleted from the data set. As before, the first block of trials in each half was considered practice and did not figure in the results. Median RT was calculated for each subject within each level of the Background, SOA, Session half and Trial block variables. The means of these medians are shown in Figure 3 for the five background conditions as a function of SOA. The means collapsed across SOAs are shown at the right of the figure. A line representing a slope of -1 is shown between SOAs of 17 ms and 33 ms immediately below the single target data.

Mean RT is once again shortest in the single target condition. Unlike Experiment 1, differences are also evident among the four conditions that employed background objects. Mean RT is longest in the organized/inappropriate condition followed in order by the unorganized/inappropriate condition, the organized/appropriate condition and the unorganized/appropriate condition. With the exception of the unorganized/inappropriate condition, this order of conditions maintains consistently across all levels of SOA. RTs decline gradually across the shorter SOAs with evidence of asymptotic performance at SOA of 67 ms for the single target condition and the organized/inappropriate condition.
Experiment 2

Figure 3. Mean response time for each background condition in Experiment 2 as a function of SOA.
At SOA of 17 ms, mean RT in the unorganized/inappropriate condition is the shortest of the four conditions that employed background objects. Response time in this condition then increases at SOA of 33 ms and fluctuates thereafter ending up slightly less than the organized/inappropriate condition at SOA of 100 ms. There is no strong tendency for performance in any of the conditions to converge with increasing SOA. In fact, there is some indication that the difference between appropriate and inappropriate background conditions becomes larger with increasing SOA.

Figure 4 shows the means for each of the five background conditions as a function trial block and session half. Response times show a tendency to decline as a function of trial block in the first half and maintain at a generally lower level throughout the second half. In the first half, there appears to be some tendency for performance in the four conditions that employed background objects to become equal by the third trial block. However, this pattern did not occur in the second half.

The data were submitted to a four-way, repeated-measures ANOVA with Background, SOA, Trial block, and Session half serving as within subjects factors. Mean RT differed reliably among the five background conditions, $F(4, 92) = 38.10, p < .001$. Mean RT also differed among the five levels of SOA, $F(4, 92) = 5.18, p < .001$. The Background by SOA interaction was not statistically reliable, $F(16, 368) = 1.23, p = .239$. None of the interactions involving Background, Trial block and Session half were statistically reliable. For both the Background by Trial block and the Background by Session half interactions, $F_s < 1$. 
Experiment 2

Figure 4. Mean response time for each background condition in Experiment 2 as a function of Session half and Trial block.
For the Background by Trial block by Session half interaction, \( F(8,184) = 1.32, p = .237. \)

A series of \( t \) tests was performed on differences between consecutive SOAs in each of the five background conditions. None of these \( t \) tests proved to be statistically reliable.

In order to determine the extent to which performance varied among the four conditions that employed background objects, each of these conditions was coded for organization (organized vs. unorganized) and for appropriateness of background objects (appropriate vs. inappropriate) and a three-way, repeated-measures ANOVA was performed with Organization, Appropriateness and SOA serving as within subjects factors. Response times with organized backgrounds were reliably slower than RTs with unorganized backgrounds, \( F(1,23) = 12.39, p < .01. \) Response times with inappropriate backgrounds were reliably slower than RTs with appropriate backgrounds, \( F(1,23) = 18.33, p < .001. \) The Organization by Appropriateness interaction was not statistically reliable, \( F < 1. \) Response times differed among the five levels of SOA, \( F(4,92) = 4.76, p < .01. \) The Organization by SOA interaction was not statistically reliable, \( F(4,92) = 1.03, p = .396. \) However, the difference between appropriate and inappropriate backgrounds did vary as a function of SOA, \( F(4,92) = 2.50, p = .048. \) The Organization by Appropriateness by SOA interaction was not statistically reliable, \( F < 1. \)

Error rates were calculated and submitted to a two-way, repeated-measures ANOVA with Background and SOA serving as within subjects variables. Error rates did not differ among the five levels of Background, \( F < 1, \) nor among the five levels of SOA, \( F(4,92) = 1.83, \)
p = .130. However, the Background by SOA interaction was statistically reliable, \( F(16,368) = 2.05, p = .010. \)

**Discussion**

As in Experiment 1, RTs were slower when background objects were present than when the target was presented alone. However, the reliable main effects of Appropriateness and Organization indicate that background objects in the present experiment affected performance above and beyond their mere presence. Because the primary difference between Experiment 1 and the present experiment was simply the spacing of objects, object spacing or density appears to be an important factor in determining whether or not high level characteristics of background objects affect performance.

Because attention is a spatially localized region of processing activity, stimulus spacing effects often reflect the involvement of attention. This is a particular concern in the present experiment because the change in spacing brought objects closer together. An important question, therefore, is the extent to which the differences among backgrounds may have been mediated by attention. The data in Figure 3 show that RTs tend to decline gradually with increasing SOA, indicating that at least some attentional focusing was occurring. The reliable main effect of SOA supports this conclusion. The one exception appears to be the unorganized/inappropriate condition in which RT actually increases between SOAs of 17 ms and 33 ms. However, the fact that there is no theoretical basis for interpreting such an increase, and the fact that RT in this condition fluctuates a great deal across the remaining SOAs, suggests that the increase may be interpreted as noise. To the extent that the effect of background objects is mediated
by attention, we would expect the effect to become smaller as attention becomes more focused. There is no indication that this is happening. If anything, the differences among backgrounds become larger with increasing SOA and this is supported by the reliable SOA by Appropriateness interaction. Thus, there is no evidence of a relationship between focal attention and the processing of background objects.

Although the differences among backgrounds in the present experiment arose because objects were moved closer together, the nearest background object was still centered more than one degree from the target. Therefore, background objects should have fallen outside the focus of attention when attention was focused on the target. However, it is difficult to determine the exact point at which attention arrived at the target location because none of the SOA functions decline sharply with slopes approaching the value of -1. Although this may indicate that approximately 17 ms was sufficient time for attention to move to the location of the target, the reliable main effect of SOA suggests that there was at least some attentional focusing occurring beyond 17 ms. The point at which attention arrived at the target location can be estimated from the information in Experiment 1. In Experiment 1, asymptotic performance was reached in the single target condition at an SOA of 83 ms. Thus, it took approximately 83 ms for attention to move the 4.31 degrees to the location of the target. Based on these figures and the present target distance of 2.81 degrees, an estimate of the time to move attention to the target location in the present experiment would be approximately 50 ms. Given this estimate, it is interesting to note that there is no strong tendency for RTs to decline beyond the 67 ms
SOA. We may be fairly confident, therefore, that attention was focused on the target by 67 ms, and perhaps as early as 17 ms. The clear differences among the various background conditions at SOAs of 67 ms and 100 ms suggests that background objects affected performance even after attention was narrowly focused on the target stimulus.

The pattern of gradually declining RTs is typical of the results of Eriksen and his colleagues (Eriksen & Hoffman, 1972b; Hoffman, 1975) who rarely find SOA functions with slopes approaching -1. Interestingly, the targets in Eriksen's work are also spaced relatively close to fixation. Evidence of attentional movement may therefore require that the target be spaced relatively far from fixation. The evidence for focusing in the absence of attentional movement suggests that there may be some component of attentional focusing that is unrelated to movement.

The reliable main effect of Appropriateness suggests that background objects are processed to a semantic level. The present pattern of interference for inappropriate objects does not fit the results of Underwood (1976) and is not subject to Broadbent's (1981) partial perception interpretation. The present results are more similar to results obtained in word recognition research which shows that response to a word is facilitated by the prior presentation of a semantically related word prime and inhibited by the prior presentation of an unrelated word prime (Becker, 1979; Becker & Killion, 1977; Neely, 1976). This similarity suggests that the effect of appropriateness in the present experiment is based on the semantic processing of background objects.

The effect of appropriateness for organized backgrounds replicates Biederman's results (Biederman, 1981; Biederman, Mezzanotte &
Rabinowitz, 1982) that objects are perceived more poorly when they violate meaningful relationships that exist among objects in real world scenes. However, the difference between appropriate and inappropriate objects was just as large when the objects were unorganized. Therefore there is at least some semantic processing of background objects even when they are not organized.

The main effect of Organization indicates that there is some characteristic of organized scenes that affects performance above and beyond the individual objects that form those scenes. This is consistent with the view that scene organization reflects a global form of information which is based on meaningful relationships among objects. The fact that the difference between appropriate and inappropriate objects was just as large when the objects were unorganized, however, indicates that the effect may not be solely attributable to meaningful relationships among objects.

It is an interesting fact that the effect of organization is one of interference, particularly with respect to the appropriate backgrounds. The poorer perception of objects in the organized/appropriate condition directly contradicts Biederman's (1972) original finding that objects are perceived better in coherent scenes than in jumbled scenes. This brings into question whether or not the effect of organization truly reflects the organization in scenes. Apart from the apparent coherency of organized backgrounds, organized backgrounds differed from unorganized backgrounds by the presence of a horizon line. It may be that the horizon line alone in some way interfered with target identification. However, there was a horizon line present in the organized scenes in Experiment 1 and no such interference occurred.
Although the horizon line was positioned differently in Experiment 2 such that the target object occluded part of the line, there is no strong reason to believe that this alone could have produced the obtained interference.

One potentially important difference between Biederman's research and the present experiment is that in the present experiment, a small set of stimuli were presented repeatedly over trials. Although the results of Biederman, Teitelbaum and Mezzonnotte (1983) indicate that this is not an important factor with up to five repetitions of the same background, each background in the present experiment was viewed a total of thirty times in each its right and left orientation. This large number of repetitions may have produced substantial changes in the pattern of responding. However, none of the interactions involving Background, Trial block and Session half proved to be statistically reliable, so there is no indication of any specific or general background related learning effects.

The effect of organization therefore appears to be due to the processing of scene related information. A last possibility to consider is that the interference from organized backgrounds, particularly with appropriate background objects is due to some procedural difference between Biederman's (1972) experiment and the present one. Although Biederman (1972) employed a condition in which the location of the target was precued, the cue preceded target onset by 500 ms. Experiments 1 and 2 show that most of the effect of cuing occurs at relatively short SOAs. It is not necessarily clear, therefore, to what extent Biederman's precue was controlling the focus of attention at the time of stimulus onset. Johnston and McClelland (1974) investigated the
effect of location cuing in a letter identification task in which the
target letter was presented in a meaningful word and in a random string
of letters. In one condition, the location of the target letter was
precued and in another condition subjects were instructed to attend to
the entire letter string. The important finding was that location cuing
improved performance with random strings of letters, but actually hurt
performance with words.

The difference between a word and a random string of letters is
similar to the difference between an organized and unorganized
arrangement of real world objects. The pattern of results in the
Johnston and McClelland (1974) study suggests a possible explanation for
the interference with organized/appropriate scenes in the present
experiment. The precuing manipulation may have helped sufficiently in
the unorganized/appropriate condition and hurt sufficiently in the
organized/appropriate condition to yield the obtained pattern of
results. To the extent that this is true, an advantage for the
organized/appropriate condition might emerge if no location cues were
used and subjects were instructed to attend to the entire arrangement of
objects.

Experiment 3

To determine if organization affects performance differently
depending on whether or not precise target location information is
present, a no-cue condition was introduced in Experiment 3. In
alternating blocks of trials, the target's location was either precued
across a range of four SOAs or no location cue was presented at all.
The range of SOAs included the three shortest SOAs in Experiment 2 plus one of 117 ms. This longer SOA was employed to determine whether or not the tendency in Experiment 2 for RTs in the appropriate and inappropriate background conditions to diverge would become even more pronounced.

Method

Design. Each session was composed of ten blocks of trials with eighty trials in each block. Each block was devoted exclusively to either the precue or the no-cue condition, and cue condition was alternated on a block by block basis. The eighty trials in each block reflected the forty possible combinations of five background conditions, four levels of SOA (17 ms, 33 ms, 50 ms, and 117 ms), and two locations (left or right) for each of the two targets. In the no-cue condition, the twenty possible combinations of background, location and target were repeated four times within the trial block.

Each session was devoted exclusively to one of the six possible target stimulus pairs. The target stimulus pairings, the cue condition of the first block of trials, and the response button (right or left) assigned to each target in the pair were counterbalanced across subjects.

Subjects. The subjects were 24 Rice University graduate and undergraduate students (15 female). The graduate students were members of the Psychology department and volunteered their services. The undergraduates either received course credit or were paid for their services.

Apparatus and stimuli. The apparatus and stimuli were identical to Experiment 2.
Procedure. Subjects were tested individually in a single session lasting approximately one hour. The basic procedure was similar to that described in previous experiments. On trials for which no location cue was presented, the fixation cross appeared as before and was replaced after 500 ms by the stimulus display. On no-cue trials, subjects were instructed that, because the target location would be determined randomly on each trial, the best strategy was to spread their attention across the entire display rather than to focus on one or the other of the two locations. After each block of trials, subjects were informed not only of the number of errors committed in the previous block, but also as to whether the next block of trials employed locations cues.

Results and discussion

All trials on which RTs were less than 200 ms or greater than 2000 ms were considered errors and were deleted from the data set before analyses were performed. The first block of trials in each the precue and the no-cue conditions was considered practice and did not figure in the results. The median correct RT was calculated for each subject for each level of the Cue, Block, Background and SOA variables.

Figure 5 shows the means of these medians for the five background conditions in the no-cue condition, the precue condition as a function of SOA, and the means collapsed across SOA. A line representing a slope of -1 is shown between SOAs of 17 ms and 33 ms immediately below the data from the single target conditions. Inspection of the no-cue data shows that RTs in all five background conditions are considerably faster than in the precue condition. There is a considerable advantage for the single target condition over the four conditions that employed background objects. Among these four conditions, RTs are faster with
Experiment 3

Figure 5. Mean response time for each background in the no-cue condition and the precue condition of Experiment 3 as a function of SOA.
appropriate objects than with inappropriate objects although there is no difference between organized and unorganized backgrounds.

In the precue condition, RT is consistently faster in the single target condition than in the four conditions that employed background objects. This advantage maintains across all levels of SOA. Response time in the single target condition declines across the shortest SOAs (particularly between 33 ms and 50 ms), but shows no strong tendency to decline further thereafter. Among the four conditions that employed background objects, there is an initial decline in RT between SOAs of 17 ms and 33 ms that is especially sharp for the organized backgrounds. There is no strong indication the RTs decline further after 33 ms although RTs for both inappropriate backgrounds increase from 33 ms to 50 ms and then decline again by 117 ms. A larger interference effect for organized backgrounds is evident at an SOA of 17 ms, but essentially disappears by 33 ms. There is an increase in RT between SOAs of 33 ms and 50 ms for all four conditions, but this tendency is most pronounced for the inappropriate backgrounds. Except for the unorganized/appropriate condition, RTs tend to decline between SOAs of 50 ms and 117 ms.

Figures 6 and 7 show the means for the five background conditions as a function of Trial block for the no-cue condition and the precue condition respectively. Although RTs tend to decline as a function of Trial block, there is no indication that systematic changes occur in the pattern of results as a function of practice.

Analyses on no-cue data. The no-cue data were submitted to a two-way, repeated-measures ANOVA with Background and Trial block serving as within subjects factors. Mean RT differed reliably among the five
Figure 6. Mean response time for each background in the no-cue condition of Experiment 3 as a function of Trial block.
Figure 7. Mean response time for each background in the precue condition of Experiment 3 as a function of Trial block.
background conditions, $F(4, 92) = 28.15, p < .001$. Mean RT also differed among Trial blocks, $F(3, 69) = 6.09, p < .01$. However, the Background by Trial block interaction was not statistically reliable, $F(12, 276) = 1.22, p = .268$.

A one-way, repeated-measures ANOVA on error rates indicated that error rates differed reliably among the five background conditions, $F(4, 92) = 2.54, p = .045$. However, mean error rate was lowest in the single target condition (.035) and highest in the unorganized/inappropriate condition (.056) indicating no tendency for a speed/accuracy trade off.

The single target data were deleted and a two-way, repeated-measures ANOVA was performed using Organization and Appropriateness as the between subjects factors. There was no reliable effect of Organization, $F < 1$. However, mean RT was reliably shorter for appropriate background objects than for inappropriate objects, $F(1, 23) = 18.25, p < .001$.

**Analyses on precue data.** Data in the precue condition were submitted to a three-way, repeated-measures ANOVA with Background, SOA and Trial block serving as the within subjects factors. Mean RT differed reliably among the five background conditions, $F(4, 92) = 19.61, p < .001$. Mean RT also differed among the four levels of SOA, $F(3, 69) = 8.89, p < .001$. The Background by SOA interaction approached statistical reliability, $F(12, 276) = 1.77, p = .053$. The Background by Trial block interaction was not statistically reliable, $F(12, 276) = 1.32, p = .206$.

A two-way, repeated-measures ANOVA was performed on error rates in which Background and SOA served as within subjects factors. The
difference in error rate among the five background conditions approached statistical reliability, $F(4,92) = 2.11, p = .086$. However, mean error rate was lowest in the single target condition (.024) and highest in the unorganized/inappropriate condition (.044) indicating no tendency for a speed/accuracy trade off. The difference in error rate among the five levels of SOA also approached statistical reliability, $F(3,69) = 2.41, p = .073$. Mean error rate was lowest at SOA of 33 ms (.031) and highest at SOA of 50 ms (.045). The Background by SOA interaction was not statistically reliable, $F(12,276) = 1.04, p = .413$.

A series of $t$ tests was performed on the differences between consecutive SOAs in each of the five background conditions. The decline in RT between 17 ms and 33 ms was significant in the organized/appropriate condition, $t(23) = 3.75, p = .001$, and in the organized/inappropriate condition, $t(23) = 3.58, p < .010$. The increase in RT between 33 ms and 50 ms was also reliable in the organized/inappropriate condition, $t(23) = 2.17, p = .041$. The decline was marginally significant in the unorganized/appropriate condition, $t(23) = 1.97, p = .062$, and in the unorganized/inappropriate condition, $t(23) = 1.88, p = .073$.

The data from the single target condition were deleted and a three-way, repeated-measures ANOVA was performed using Organization, Appropriateness and SOA as within subjects factors. Mean RT was reliably slower for organized backgrounds than for unorganized backgrounds, $F(1,23) = 6.14, p = .021$. Mean RT was reliably slower with inappropriate background objects than with appropriate background objects, $F(1,23) = 15.17, p < .001$. The Organization by Appropriateness interaction was not statistically reliable, $F(1,23) =$
1.95, \( p = .176 \). Mean RT differed as a function of SOA, \( F(3, 69) = 10.03, p < .001 \). The SOA by Organization interactions approached statistical reliability, \( F(3, 69) = 2.17, p = .097 \). For both the SOA by Appropriateness and the SOA by Organization by Appropriateness interactions, \( Fs < 1 \).

**Discussion**

Present results do not support the hypothesis that failure to find a facilitation effect for organized backgrounds with appropriate background objects results from the fact that location precues reduce the influence of organization. There was essentially no difference between organized/appropriate and unorganized/appropriate backgrounds in either the no-cue condition or the precue condition. This indicates either that Biederman's (1972) original finding of better performance for coherent photographs than for jumbled photographs is an artifact of the jumbling operation itself, or that some characteristic of the present experimental procedure and/or stimuli eliminates the effect.

Apart from the systematic use of location precues, the present procedure differs from Biederman's primarily with respect to the fact that stimulus displays consisted of a small number of spatially distinct objects that were presented repeatedly over trials. Because the stimuli were not switched at the half in the present experiment, the backgrounds were repeated an even greater number of times than in previous experiments. However, there is no indication that the relationship between the organized/appropriate and the organized/inappropriate conditions changes systematically as a function of trial block in either cue condition. To the extent that Biederman's original finding was not artifactual, it may be that the present displays lack some important
characteristic of real world photographs (e.g., detail or number of objects) that would enhance the effect of organization.

Although the no-cue manipulation has essentially no effect on the processing of appropriate backgrounds, it does affect performance. Specifically, interference in the unorganized/inappropriate condition increases in the no-cue condition such that the effect of organization evident in the precue condition disappears. Although this can be taken to indicate that there is no difference between organized and unorganized backgrounds in the no-cue condition, the overall pattern of results suggests that this interpretation may not be correct. Specifically, lack of evidence for an effect of organization in the no-cue condition is due exclusively to changes that occurred with unorganized backgrounds. The precue/no-cue manipulation had essentially no effect on the difference between the two organized backgrounds. To the extent that the precue/no-cue manipulation reflects an attentional manipulation (focal vs. nonfocal attention), processing of organized backgrounds appears to be independent of the focus of attention. The processing of unorganized backgrounds, however, is at least to some extent affected by the focus of attention.

The difference between the organized/appropriate and the organized/inappropriate conditions also remains large and relatively consistent across all levels of SOA. The increase at SOA of 50 ms reflects a general pattern for RTs to increase between 33 ms and 50 ms that is simply more pronounced in the organized/inappropriate condition. Because there is no theoretical basis for such an increase, and because no similar effect was obtained in Experiment 2, this tendency can likely be attributed to noise. The important point is that precuing has
relatively little effect on processing of scene specific information with organized backgrounds.

Although the processing of organized backgrounds appears to be independent of attention, there is nonetheless a strong effect of cuing for these backgrounds. Response times decline sharply and reliably for both organized backgrounds between SOAs of 17 ms and 33 ms. Organization, therefore, appears to have a general disrupting effect on performance early in the process of focusing attention. This indicates that information regarding organization is available very rapidly.

The effect of cuing between SOAs of 17 ms and 33 ms is smaller for unorganized backgrounds although the decline in both cases approaches conventional levels of statistical reliability. The no-cue condition and the precue condition at SOA of 17 ms, therefore, both represent situations in which attention may be considered to be unfocused. The difference in the pattern of results between these two conditions suggests that there are two ways in which attention may be considered to be unfocused. One in the sense of being spread out to encompass two or more objects or locations, and another in the sense of being less than maximally focused on a given particular object or location.

There was a stronger effect of precuing in the present experiment than in Experiment 2. There was also clearer evidence of asymptotic performance in the present experiment. Aside from the fact the same stimuli were used throughout the experiment, the only obvious difference between the present experiment and Experiment 2 is blocks of no-cue trials were alternated between precue trials. Posner, Nissen and Ogden (1978) found that a strong effect of precuing was obtained only when cue expectancy was manipulated within a block of trials and not between
blocks. It may be that alternating no-cue and precue blocks increases the effectiveness of the precues.

Although the single target condition remains fastest across all levels of SOA, mean RT among the four conditions that employed background objects appears to converge at the longest SOA. This pattern suggests that the tendency toward divergence in Experiment 2 is probably not real. Do the present results, however, indicate that differences among the various backgrounds tend to disappear as attention becomes more focused? Probably not. Past research indicates that performance improves as attention becomes more focused. In fact, asymptotic performance is typically taken as evidence that attentional focusing is complete. All four RTs are slower at SOA of 117 ms than at SOA of 33 ms indicating that performance was not generally improving across this range of SOAs. In addition, none of the interactions involving SOA, Organization and Appropriateness proved to be reliable. Therefore, the tendency toward convergence cannot be considered to be particularly strong.

The major evidence for convergence lies in the fact that the effect of organization disappears across the shortest SOAs. To the extent that processing of organized backgrounds is at least partially independent of processing of unorganized backgrounds, this tendency may not reflect convergence per se, but rather, two overlapping curves that lie close to one another at SOA of 33 ms.

Although the slopes of the SOA functions are actually steeper than -1 for the organized backgrounds, the present cuing effects probably do not reflect the sole influence of attentional movement. The slopes are much shallower in the two unorganized conditions and is very shallow in
the single target condition. Because movement would occur equally in each of these conditions, it is not likely that the sharp drop in RT results from attentional movement.

The overall pattern of faster RTs in the no-cue condition was unexpected and indicates that there is some interference that can be traced to use of location precues. Kahneman, Treisman and Burkell (1983) found that the onset of distractor stimuli interfered with target identification even when the locations of the distractors were known in advance such that attention could be directed away from them. There was even some interference produced by the offset of distractors simultaneous with the onset of the target. These results were interpreted by Kahneman et al. to indicate that visual events, that is, the onset or offset of stimuli, produce some kind of distraction or event masking (in their terms, a filtering cost). The obtained interference from the location precue could represent a similar kind of masking. The processing of the cue may require a certain period of time such that the processing of other events occurring closely in time may be delayed. The delay is apparently quite substantial in that if the onset of the single target in the no-cue condition serves as its own location cue, then performance in this condition represents an SOA of 0 ms. Based on the pattern of results obtained with the single target in the precue condition, the mean RT at SOA of 0 ms should be in the vicinity of 610 ms to 620 ms. A reasonable minimum estimate of the amount of interference would therefore be approximately 60 ms. The fact that there was essentially no difference in the pattern of results between the precue and no-cue conditions (except for the
unorganized/inappropriate condition) suggests that the mere presence of the precue does not alter the effect of background objects.

General Discussion and Conclusions

The evidence in Experiment 1 indicates that the processes which underlie identification of target objects in the present series of experiments are similar to those which underlie the identification letter stimuli. The sharp initial decline in RTs with slopes approaching the value of -1 and the clear evidence of asymptotic performance in the single target condition support the conclusion that attention moves to the location of the target and that very little information is available until after the target is localized. The fact that RTs did not generally decline sharply in Experiments 2 and 3 after target objects had been moved closer to fixation indicates that strong evidence of attentional movement may require relatively large object spacings.

Although no consistent evidence of attentional movement was obtained with closer target object spacings (Experiments 2 & 3), mean RT nonetheless did decline as a function of SOA. This occurred in the single target condition as well as in conditions that employed background objects. This is consistent with other results (e.g., Eriksen & Hoffman, 1972b; Hoffman, 1975) obtained using small target spacings and suggests that there may be a component to attentional focusing that is to some extent independent of movement. Some support for this conclusion also comes from Experiment 1. Asymptotic performance was reached in the single target condition at an SOA of 83
ms indicating that attention had stopped moving by this time. However, there was some tendency for RTs in the four conditions that employed background objects to decline further at the longer SOAs suggesting that additional focusing was occurring after attention had stopped moving.

The exact nature of this focusing process is not clear although present data suggest that it does not reflect a contraction of the attentional spotlight. Fairly strong evidence of focusing was obtained in the precue condition of Experiment 3. However, the pattern of results when attention was least focused (i.e., SOA of 17 ms) was not similar to that obtained when the attentional spotlight was presumably expanded (i.e., no-cue condition of the same experiment).

The important issue in the present series of experiments was the processing of background objects. In particular, the level of information available from background objects. There is evidence across all three experiments that background objects interfere with target identification. Much of this interference can be attributed to the mere presence of distractor objects in the visual field. The presence of objects, however, does not appear to disrupt the process of focusing attention because the interference generally maintains across all SOAs. The possible exception in Experiment 1 may indicate that background objects can be focused out given sufficient time and large enough object spacings.

The reliable effects of organization and appropriateness in Experiments 2 and 3 indicate that high level semantic characteristics of background objects also affect performance. Because these differences emerged only after objects were moved closer together, the question of the role of attention in mediating the effects is a particularly
important one. There is no indication in Experiment 2 that the effects became smaller or in any way changed systematically as a function of SOA. This pattern was not replicated in the precue condition of Experiment 3 as the difference between organized and unorganized backgrounds does disappear across the shortest SOAs. However, the difference between organized/appropriate and organized/inappropriate backgrounds remains large across all SOAs suggesting that processing of organized backgrounds is unaffected by the focus of attention.

Because there is at least some evidence of attentional focusing with unorganized backgrounds, processing does not appear to reflect a failure of selectivity in the sense that background objects pull attention away from the target. Rather, background objects appear to be processed on the fringe of attention. Thus, the effect of appropriateness becomes larger when attention is spread out in the no-cue condition. Because the background objects were spaced beyond one degree from the center of the target and should fall outside the focus of attention, it appears that the minimum size of the attentional spotlight may vary to some extent with the size of the stimuli employed. The stimuli in the present experiments were large by conventional standards. This is consistent with the findings of Eriksen and Schultz (1979) that the extent to which distractors affect target identification varies with the relative size of the target and distractors.

The reliable effects of organization in Experiments 2 and 3 indicate that there is some characteristic of organized backgrounds which affects performance above and beyond the identities of the individual objects. The fact that no main effect of organization was obtained in the no-cue condition of Experiment 3 shows that the effect cannot be solely
attributed to the presence of the horizon line. Unlike Treisman and Gelade's (1980) letter displays, therefore, objects in organized backgrounds are at least to some extent localized without focal attention.

Although this, too, might reflect the processing of objects on the fringe of attention, the evidence suggests that processing of objects in organized backgrounds is relatively unaffected by the focus of attention. The difference between the organized/appropriate and the organized/inappropriate conditions was as large in the no-cue condition of Experiment 3 as it was in the precue condition. In fact, this difference is the most consistent finding in Experiments 2 and 3. The fact that organization reflects a high level form of information that is global in nature and not dependent on focal attention indicates that there is an important source of information in real world contexts that has been ignored in the traditional attention research.
Appendix A

Organized and Unorganized Stimulus Displays Used in Experiment 1
Appendix B

Organized and Unorganized Stimulus Displays Used in Experiment 2
Reference Notes

References


