Visual Search: A Novel Psychophysics for Preattentive Vision

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Abstract

An important component of visual search is the preattentive guidance of attention towards a target item. The purpose of this investigation is to determine a tuning curve for these guidance mechanisms. The experiments utilize an oriented grating to mask preattentive guidance in a visual search for orientation. By systematically varying the orientation of the grating, we expected to determine the tuning curve for preattentive guidance mechanisms. The results, however, suggest that we found a tuning curve for early visual processing of unattended stimuli.

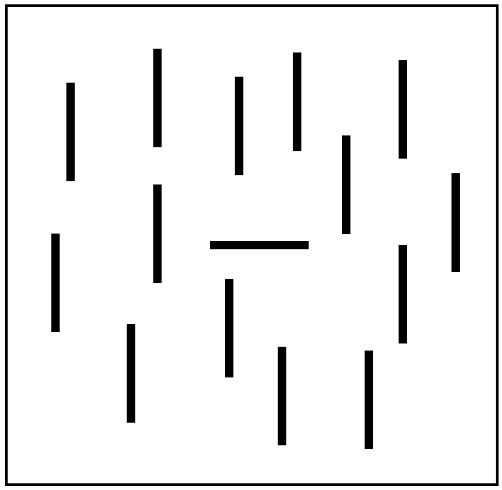

Figure 1: Parallel search for a horizontal target among vertical distractors. The target seems to “pop out” of the display.

1 Introduction

1.1 Visual Search

A human performs hundreds of visual searches each day: looking for the car keys, finding a friend in a crowd, and searching for that ever-elusive parking space. In a cluttered visual world, humans are able to find what they are looking for with amazing efficiency. For the past fifteen years, cognitive scientists have been making breakthroughs in the mechanics of this visual search process. In the lab, most visual search investigations involve a subject searching a computer display for a target item among a certain number of distractor items. In half the experimental trials, or individual computer displays, the target is present (target trials), and in the other half, it is absent (blank trials). To determine how efficiently subjects can complete a given search task, investigators study the relationship between set size–the number of items in the search display–and reaction time (RT)–the time it takes a subject to respond that the target is either present or absent.

Initially, scientists believed there were two separate types of mechanisms for finding a target: parallel and serial mechanisms. In a parallel search, one basic feature, such as color,

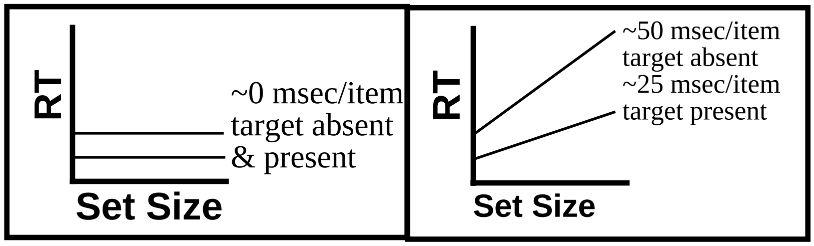

Figure 2: Typical graphs of reaction times for target present and absent trials. (a) In a parallel search, the slope of the reaction time plotted against the set size is 0 because increasing the number of distractors in the display does not change the reaction time. (b) In a serial search, the slope is positive because the number of distractors does affect reaction times.

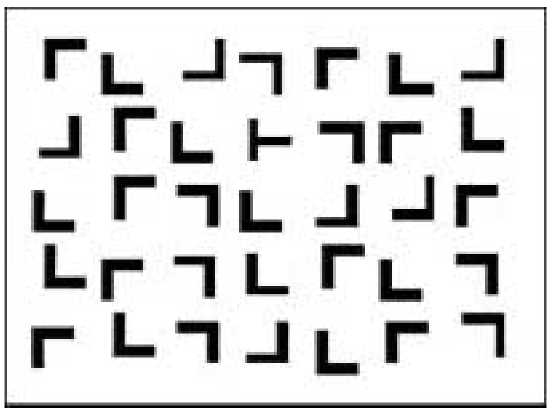

Figure 3: A typical serial search is searching for T's among L's. The common explanation for this search is a randomly attending to items in the display until the T is found.

motion, or orientation, distinguishes the target from the distractors. For instance, in a search for a horizontal line among vertical lines, the target differs from the distractors by the basic feature of orientation (Fig. 1). The horizontal line seems to "pop out" from the distractors suggesting that all items are processed at once, or in parallel. Figure 2a is a schematic of typical data for such an experiment. Because increasing the number of distractors does not significantly increase reaction time, the slope of the set size plotted against reaction times in a parallel search is approximately zero.

In a serial search, on the other hand, the target is not distinguished from the distractors by a single basic feature. An example of a serial search, looking for T's among L's, is shown

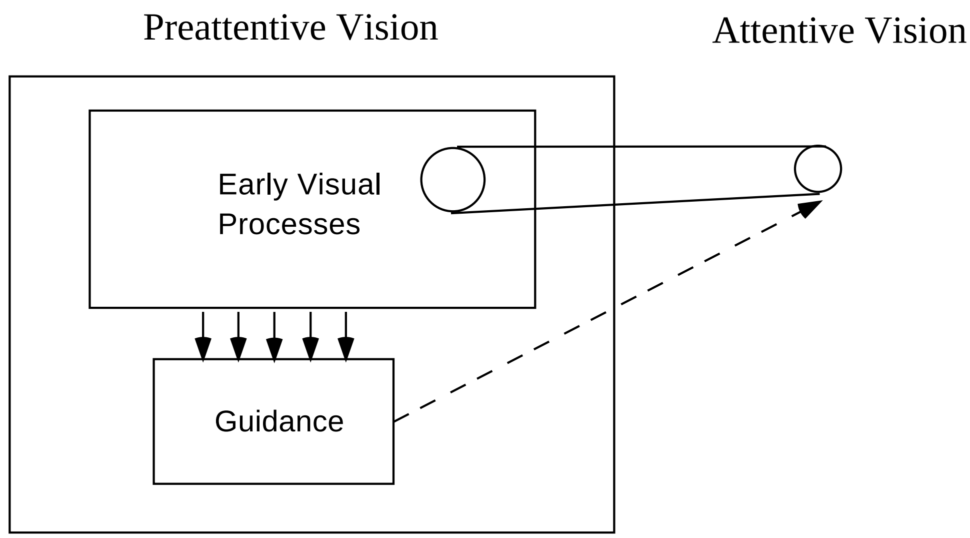

Figure 4: A flow chart of the visual search process. Preattentive processes include early vision, where edge detection and basic feature extraction occurs, and guidance mechanisms, which utilize early visual information to guide attention. Once the visual system attends to an object, processing of complex features occurs.

in Figure 3. Because a 'T' does not differ from an 'L' in any single basic feature, this search does not allow for a "pop out," parallel effect; instead, subjects must attend to the items one by one to find the 'T'. Thus, increasing the number of distractor items (i.e., 'L's) increases the reaction time, resulting in a positive slope (Fig. 2b).

With the advent of new data, however, scientists have shown that this strict parallel-serial dichotomy does not exist[1, 2, 3]. Instead, visual search appears to be a limited capacity process that involves both parallel and serial mechanisms. The Guided Search Theory divides the visual search process into two stages: preattentive and attentive[8, 2] (Fig. 4). Preattentive vision is broadly defined as the visual processes that operate before humans attend to an object. During this stage of visual search, early visual processes operate in *parallel* over a large portion of the visual field, extracting from each item basic visual features[4, 5]. This information is then transferred to two processing areas. One area is attention processing, the second stage of visual search. The other area is a component of the preattentive stage: guidance mechanisms. Guidance mechanisms use preattentive

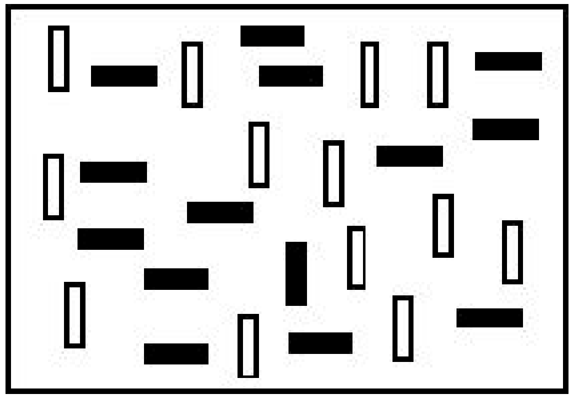

Figure 5: The target in this conjunction search is a black, vertical bar. Preattentive processes extract basic features, color and orientation, from the display. Using this preattentive information, guidance deploys attention to areas that have a high activation. The black and vertical bar usually receives the highest activation.

information to control the deployment of attention *serially*[6, 7]. During the attentive stage, the visual system attends to an item it has been guided to, deciding whether that item is the target or not. An example of search that involves guidance of attention is shown in Figure 5. Two basic features, color and orientation, define the target–a black, vertical line–in this *conjunction search*[1]. Because no single basic feature defines the target, the strict parallel-serial dichotomy would classify this search as serial. But according to the Guided Search Theory, the visual system first processes the basic features of each item in *parallel*. Using this preattentive information, the visual system serially guides attention to locations that have the same basic features, black color and/or vertical orientation, as the target. From here the visual system guides attention serially to the item with most activation, the black and vertical line, and with attention decides that, indeed, this item is the target. Because parallel processes operate during this so-called "serial" search, the concept of "guided" searches blurs the distinction between parallel and serial mechanisms.

In this paper, we study the guidance of attention in situations involving a particular basic feature: geometric orientation. Orientation is a well-studied basic feature. The standard rule

[1]A conjunction search is a search that involves two basic features.

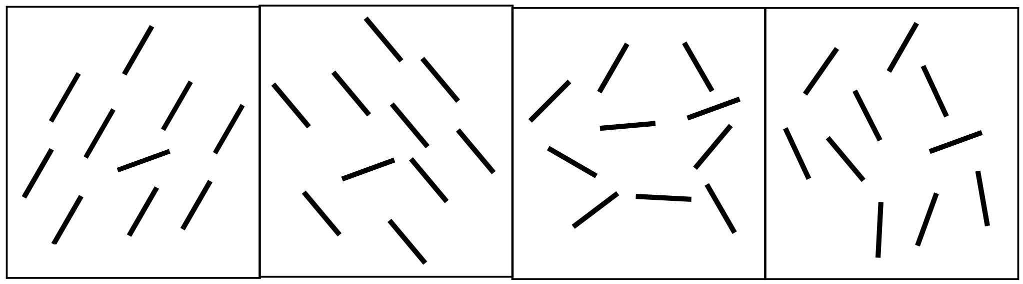

Figure 6: Orientation searches. (a)When the distractors have the same orientation (homogeneous), it is easy to find the target. (b) The greater the difference in orientation between the target and distractors, the easier it is to find the target. When the distractors have different orientations (heterogeneous), it is difficult to find the target (c) unless the target is in a unique "category", in this case "shallow" (d).

is that search efficiency[2] increases as the distractors become more homogeneous, or similar to each other, and decreases as the distractors become more similar to the target[1]. For example, search for one target orientation is quite efficient if all the distractors are the same orientation, or homogeneous (Fig. 6a). Furthermore, the greater the difference in orientation between target and distractor, the more efficient search becomes (Fig. 6b). If the distractors have heterogeneous orientations, search becomes inefficient (Fig. 6c). Wolfe *et al.*[9] have found results, however, that suggest that angular difference in orientation cannot entirely account for the data. If the target is in a unique "category", defined by Wolfe *et al.* as *steep, shallow, tilted left or tilted right*, among these heterogeneous distractor orientations, search becomes more efficient[9] (Fig. 6d). For example, in Figure 6d it is relatively easy to find the "shallow" target. Because categorization of orientations affects the efficiency of a search task, and the efficiency of a search task is largely determined by preattentive guidance, then categorization would seem to play a role in preattentive guidance. Only one study, however, has been conducted on the categorization of orientations. One goal of this paper is to confirm these results using a novel method: masking.

[2]The basic terminology of efficiency[10] is as follows: efficient is 0 msec/item, quite efficient is 5-10 msec/item, inefficient is 20-30 msec/item, very inefficient is $>$ 30 msec/item

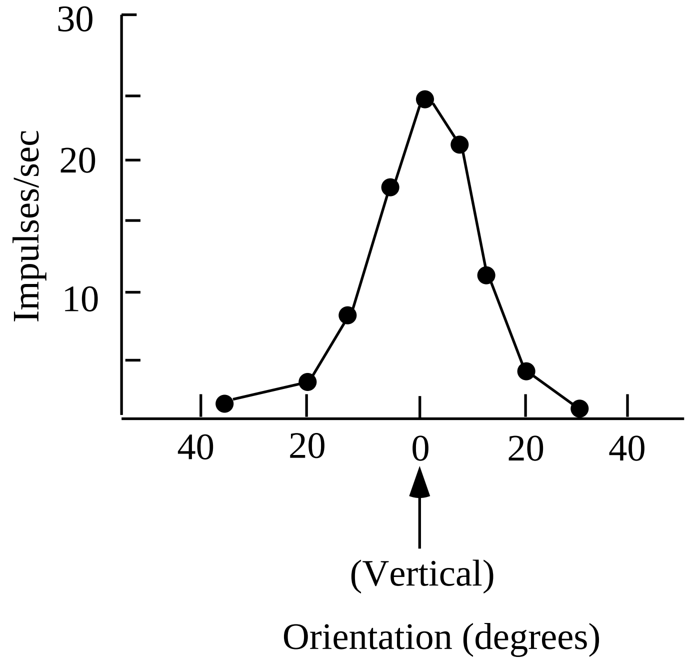

Figure 7: An orientation tuning curve of a neuron. This cells responds best to a vertical bar (orientation=0°) and responds less well as the bar is tilted to the left or right of vertical.

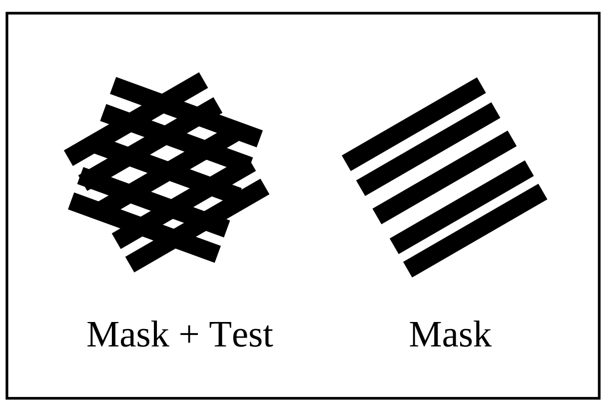

Figure 8: In a masking experiment, the subject is instructed to differentiate a mask grating placed on top of a test grating from the mask grating by itself. Both the orientation of the mask grating and the contrast between the light and dark bars of the test grating are varied.

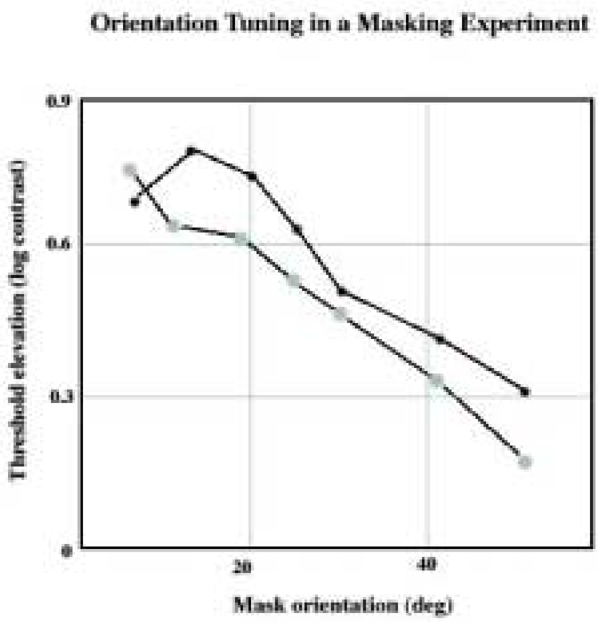

Figure 9: The threshold elevation, a number representing the difficulty of differentiating between the two stimuli, is plotted against the orientation of the mask for two subjects. The harder it is to differentiate the mask plus the test grating from the mask grating by itself, the greater the threshold elevation. The resulting graph can be interpreted as a tuning curve for the channel sensitive to the test's orientation.

1.2 Masking

One critical question is whether there exist actual mechanisms in the human brain that are sensitive specifically to these categories of orientation. Data from Wolfe *et al.* are suggestive but do not directly measure these mechanisms. Currently, there are two methods to measure such properties. The first is single cell recordings. In single cell recordings, researchers place an electrode on a single neuron in an animal's brain to measure its firing pattern when presented by a stimulus, such as an oriented bar. By plotting the number of impulses per second of the neuron against the orientation of the bar, researchers can create a tuning curve of activation for the neuron (Fig. 7). Single cell recordings, however, are not feasible in this study because the locations of these orientation-tuned cells in the human brain remain elusive.

The second method involves masking, a classic psychophysical method used to indirectly measure physical visual mechanisms operating in the brain[11]. Masking utilizes a mask, a stimulus designed to interfere with perception of a test stimulus. An example of masking is shown in Figure 8[12]. Subjects are asked to discriminate an oriented test grating presented on top of an oriented mask grating from the oriented mask grating by itself. The orientation of the mask grating is varied. When the mask's orientation is similar to the test's orientation, the subject cannot discriminate between the two stimuli unless the contrast between the colors of the light and dark bars in the test grating is high. Instead of measuring the actual responses (in impulses/sec) of individual neurons, researchers use this alternative measure–*contrast*[3]–to determine the responses of groups of neurons. The graph of the test grating's contrast plotted against the mask's orientation (Fig. 9) allows researchers to create a tuning curve for orientation channels–or groups of neurons tuned to a certain orientation–without actually studying the physical brain. A second goal of this study is to use masking to create a tuning curve for orientation channels during preattentive guidance.

Standard masking studies, however, determine tuning curves for orientation channels in

[3]Contrast represents the difficulty of discriminating between the two stimuli

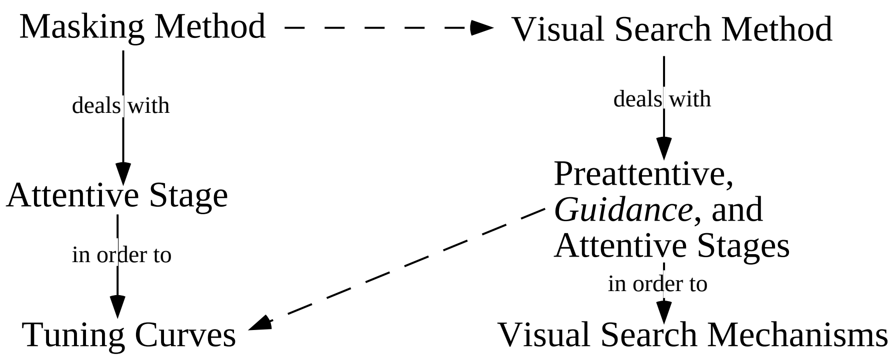

Figure 10: A flow chart demonstrating the methods and goals of this paper. We apply a masking method to a visual search task, in the hopes of defining a tuning curve for preattentive guidance mechanisms.

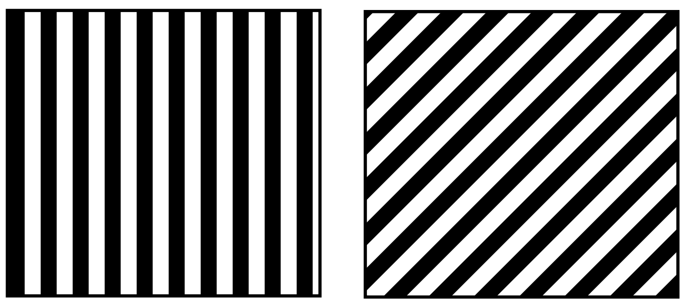

Figure 11: Two sample gratings.

only their attentive state. In this study, we apply masking methods to a visual search task, in which attention is constantly being guided, in order to determine the tuning curves for preattentive guidance mechanisms (Fig. 10). To focus solely on the preattentive stage of visual search, we try to minimize attentive stage effects, such as standard masking and adaptation[4]. Such minimization is accomplished by decreasing similarity between the items and mask. In this investigation, the mask is an oriented grating[5] that is placed as a background to the search items. By systematically varying the orientation of the grating, we hope to confirm that categorization plays a role in preattentive guidance and to create a tuning curve for guidance mechanisms.

[4]Adaptation is the process of fatiguing neurons tuned to a specific orientation so that they are less sensitive to that orientation. This effect applied to only the attentive stage.

[5]Gratings are alternating bars like those shown in Figure 11

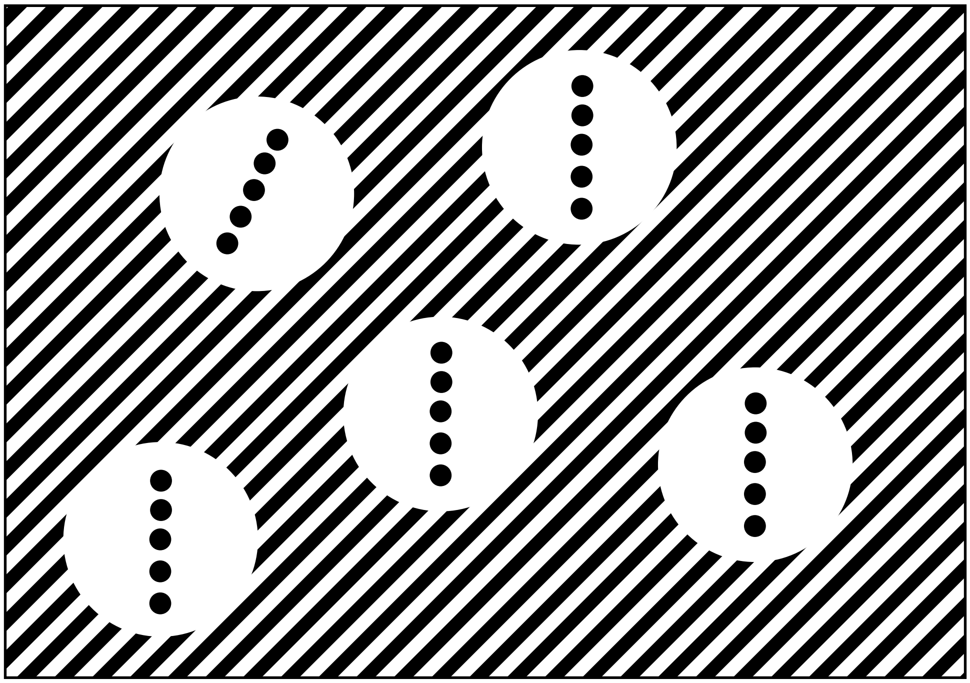

Figure 12: A sample stimulus in Experiment 1. Target and distractors are placed within blank disks on an oriented background. The target item is oriented 15° to the right of vertical and the distractor items are vertical.

2 Experiment 1: Vertical Distractors

2.1 Method

2.1.1 Stimuli

In all experiments, subjects searched for a known target item among distractor items of a different orientation on an oriented background grating. A sample trial is shown in Figure 12. Each item consisted of a 2° long line of spots (measured in terms of degrees in the visual field). By decreasing the similarity in spatial frequency between the items and the surrounding grating, the use of these lines minimized standard masking effects. The masking grating was 20° x 20° rectangular wave grating[6] of 1.1 cpd (cycles per degree). The items and

[6]A *square wave* grating alternates abruptly between light and dark bars of equal width (a *rectangular wave* grating's light and dark bars have different width). A *sine wave* grating alternates gradually between light and dark bars, with the luminance profile following the mathematical sine wave function

grating were high contrast (>95%). To provide a spatial distance between the items and the background grating, each item was placed on the background grating within a blank, white disk of 3.3° diameter, again minimizing standard masking effects. Stimuli were presented on Macintosh computers (832 x 624 pixels, 75 Hz) running MacProbe software (Hunt, 1994). Each item was presented in a 20° x 20° field. Each item was presented randomly at one of 25 locations in a slightly irregular 5 x 5 array. Two set sizes were used: 5 and 10. Targets were present on 50% of trials. On target trials, the target item replaced one of the distractor items, so the set size remained constant. Set size, positions of target and distractors, and the presence of a target were randomized across trials.

Trials began via a key press. The background grating was presented 400 ms before the stimuli. Because of video refresh, items at the top of the display could appear up to 17 ms before items at the bottom. Subjects responded to the display by pressing one of two keys: a *yes* key if the target had been detected and a *no* key if it had not been detected. Reaction times (RTs) were measured from the onset of the display. Each display remained visible until the subject responded, after which feedback (verity of response and reaction time) appeared. Subjects were given 5 practice trials followed by 250 experimental trials (50 per condition). All experiments in this paper were variations of this visual search paradigm.

There were five conditions in Experiment 1, four with the background grating present and one without it. In all conditions, subjects searched for a target item tilted 15° to the right among vertical (0°) distractors. In the "grating-present" conditions, the orientation of the grating varied as 0° (vertical), 45°, 90° (horizontal), and 135° or -45° (negative values to denote orientations tilted to the left of vertical). Figure 1 gives an example of the "grating-present" condition. Each of the five conditions was run in a separate block of 50 trials. Subjects were shown the target and distractor items before each block. Order of blocks was pseudorandom across subjects.

2.1.2 Subjects

Eleven subjects were tested. All gave informed consent and were paid for their participation. All 11 subjects had normal or corrected to normal vision.

2.2 Results

Average RTs and standard errors for target present trials for Experiment 1 are shown in Figure 13 and Appendix A. The graphs of the slopes between the set size 5 and set size 10 conditions are shown in Figure 15. As expected, the searches with no mask are very efficient; increasing the set size from 5 to 10 only slightly increases the average reaction time. As evidenced by the standard error bars, the reaction times for all mask conditions, except the 90° mask condition, are significantly greater than those for the no-mask condition. The reaction times for the 90° mask condition were low compared to those for the other mask orientations. The average reaction times for the 45° and -45° grating were significantly greater than those for the 90° mask with p-values of 0.043 and 0.0087, respectively, for the set size 5 condition. P-values for set size 10 were lower than those for set size 5. Although the average reaction time for the 45° mask was greater than that for the 0° mask in the target present condition, the difference was not significant. The slopes of the reaction times between set size 5 and set size 10 indicate that the presence of the mask greatly interfered with guidance to the target, except in the case of the 90°

There was a dramatic range of reaction times for this task, with some subjects capable of very efficient searches and others not. There is, however, no evidence for a speed-accuracy trade-off. Those subjects making more efficient searches do not make more errors.

2.3 Discussion

In contrast to our to predictions, the results do not appear to reflect categorization of orientations. If categorization had played a role in this experiment, then when the grating was

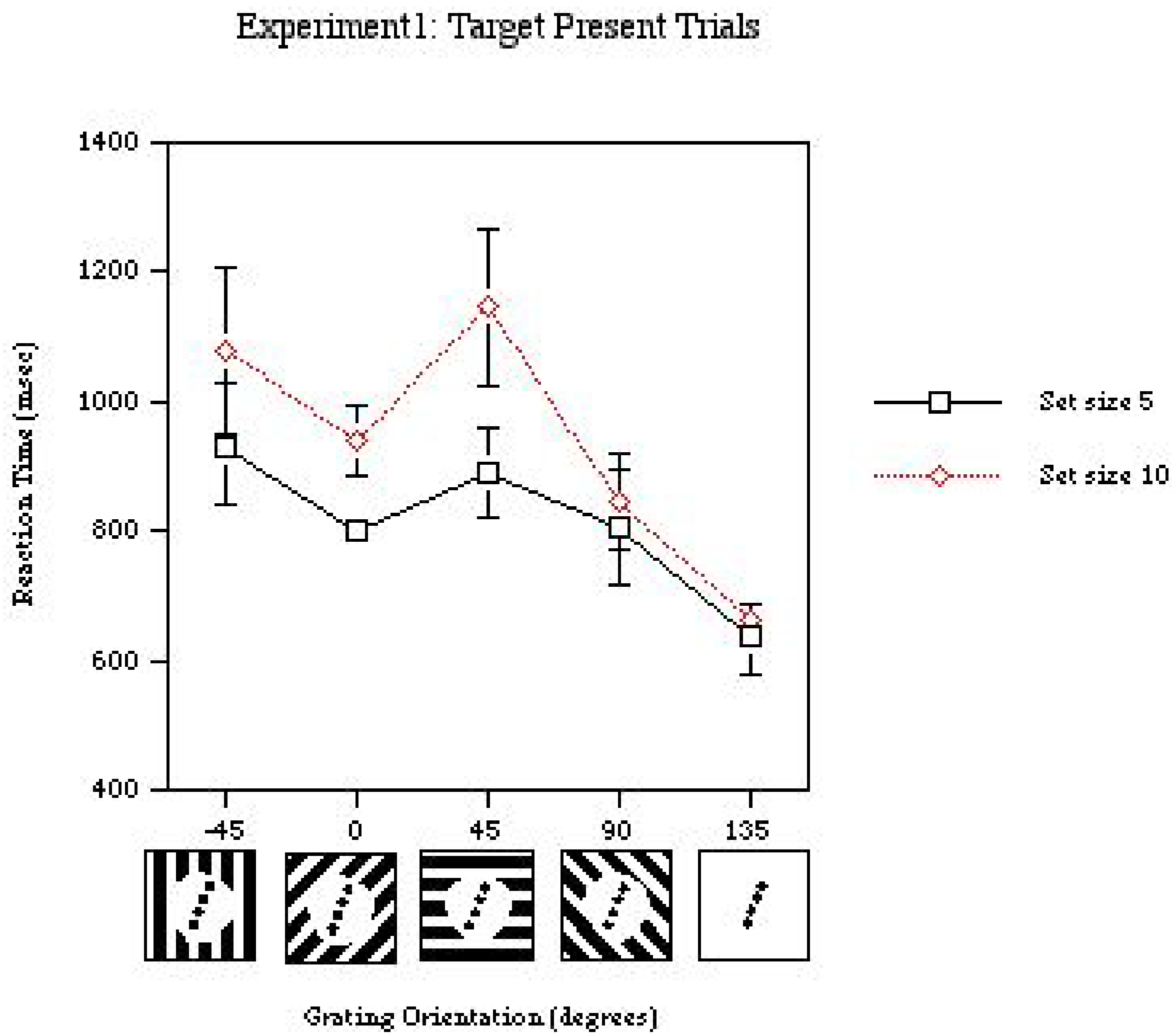

Figure 13: Target present results of Experiment 1: The average reaction times for both set size 5 and 10 conditions are plotted against the mask orientation. 135° represents the no-mask condition.

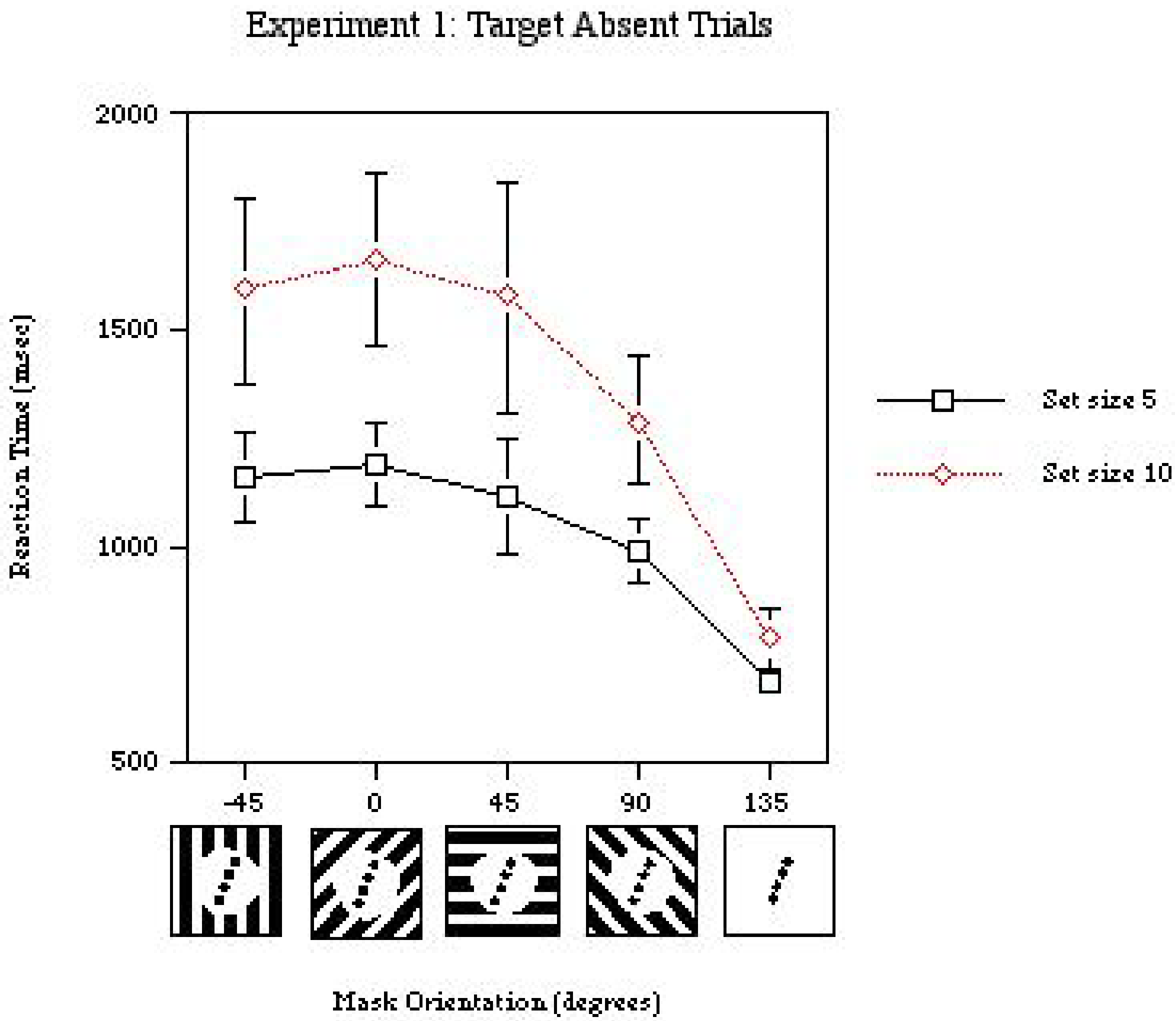

Figure 14: Target absent results of Experiment 1: As expected, the reaction times are greater than those for the target present trials.

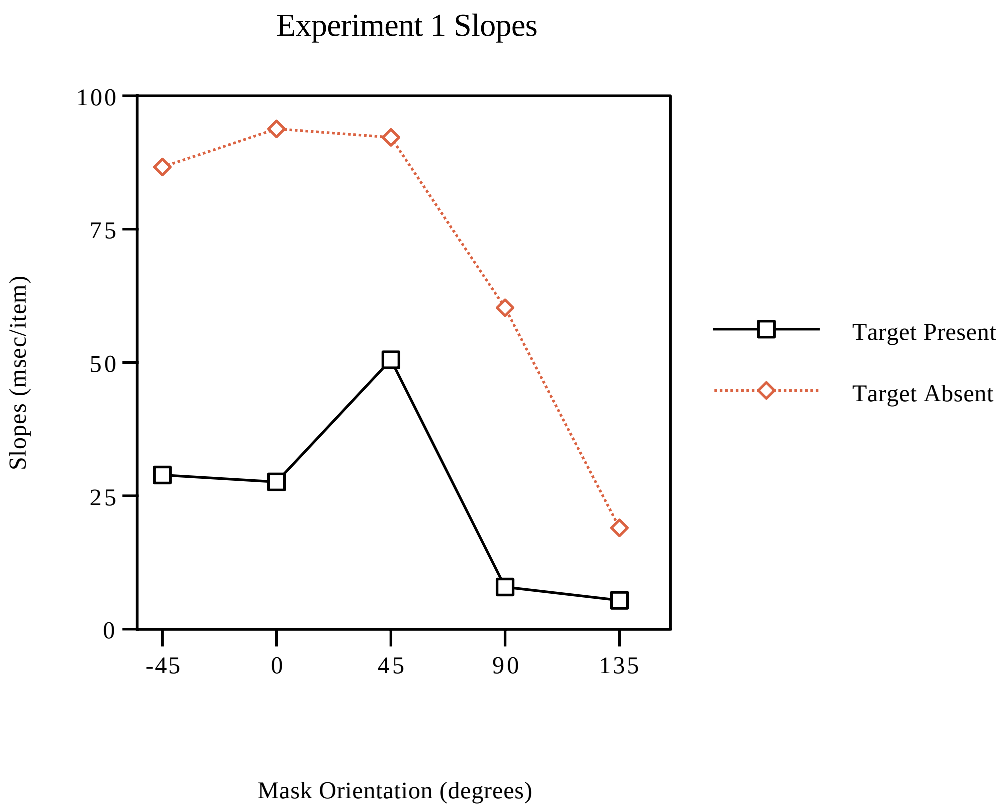

Figure 15: Graphs of slopes for Experiment 1 results: The magnitude of the slopes indicates that the mask greatly interfered with guidance to the target.

in the same orientation category as the target, it would have interfered with guidance to the target, resulting in significantly different reaction times. For instance, when the grating was 45° tilted to the right, then it was in the same "category" as the 15° tilted to the right target. According to categorization, this target would have interfered more with guidance to the target than the 0°, vertical grating, which was not in the right-tilted category. Although the average reaction time for set size 5, target present trials, and a 45° grating was greater than that for the 0° grating, the difference was not significant.

The results can be compared with standard masking results. In standard masking, the closer in orientation the mask is to the test, the more it interferes with perception of the test. Thus, the masking is based solely on the difference in orientation between the mask and test. If this were the case in Experiment 1, a 15° grating would interfere most with guidance to the 15° target. So although Experiment 1 does not utilize a 15° grating, the peak in the graph would hypothetically be located at 15°. Furthermore, if the masking were based only on the difference in orientation between the mask and target, the graph would be symmetrical. The results, however, show that the graph is not symmetrical around a hypothetical peak at 15°; instead, at 0°, the graph dips to 804.2 msec from 892.7 msec at 45°. One explanation for this dip in the graph is that at 0°, the mask is at the same orientation as the vertical distractors. Hence, it may have been relatively easy to find the target, the only tilted item in the display. This concept of making the search task easier is termed *facilitation*. Another difference between these results and standard masking results is that the tuning curve is relatively broad. In standard masking, once the mask is about 20° away from the test, the mask does not mask perception of the test. In Experiment 1, however, there is still a significant amount of masking at 45°, 30° away in orientation from the target. Still, apart from facilitation and a broader tuning curve, the results from Experiment 1 closely resemble standard masking results.

To clearly determine whether categorization were at play in Experiment 1, we would need to utilize more orientations of the grating. For instance, if the average reaction time for a 30° mask was significantly greater than the reaction time for the 0° mask, then we could conclude that although the masks are both 15° away in orientation from the target, the *right-tilted* mask interferes more that the non-right-tilted mask with the search task. Because Experiment 1 did not utilize a 30° mask, we cannot make this determination.

The magnitude of the slopes between set size 5 and set size 10 indicate that the presence of the mask greatly interfered with guidance to the target, except in the case of the 90° mask. Because this mask is far in orientation from both the target and distractors, we did not expect it to strongly interfere with guidance to the target.

This experiment differs from standard masking experiments in the presence of a new variable: the orientation of the distractors. To determine the effect of this new variable, in Experiment 2, we changed the orientation of the distractors from vertical to left-tilted.

3 Experiment 2: Left Tilted Distractors

3.1 Method

A sample trial of Experiment 2 is shown in Figure 16. There were 11 conditions in Experiment 2. The target (1° long) was tilted 10° to the right and the distractors were tilted 10° to the left of vertical. The grating was a 14° x 14° rectangular-wave grating of 1.3 cpd. The items were placed on the background grating within a blank, white disk of 2° diameter. In 10 of the 11 conditions, the background grating was present. The orientation of the grating varied as 0°, ±10°, ±30°, ±60°, ±80°, and 90°. An example of the "grating-present" condition is shown in Figure 16. There were 100 trials per condition. In all other respects the experiments were identical to those in Experiment 1.

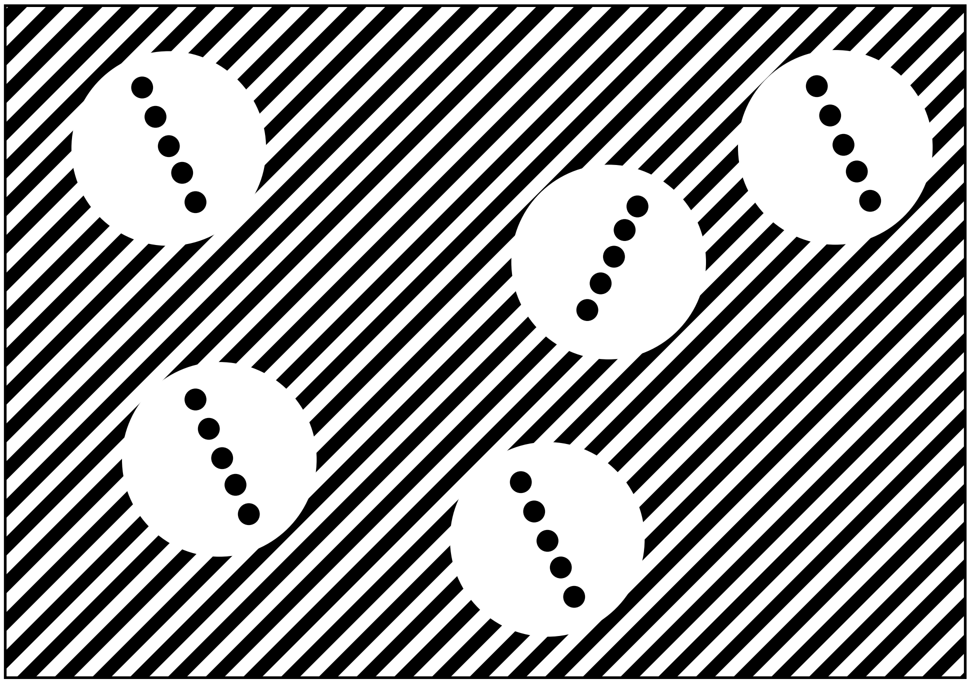

Figure 16: A sample stimulus in Experiment 2. Target and distractors are placed within blank disks on an oriented background. The target item is oriented 10° to the right of vertical and the distractor items are 10° to the left of vertical.

4 Results

Average RTs and standard errors for target present trials for Experiment 2 are shown in Figure 17 and Appendix B. The graphs of the slopes between the set size 5 and set size 10 conditions are shown in Figure 19. The basic pattern of results for Experiment 2 is similar to that for Experiment 1. T-test analysis of the results indicates that reaction times for most mask conditions[7] were significantly greater than those for the no-mask condition. The 10° mask caused the highest reaction times in both set size 5 and set size 10 conditions: 818.5 and 967.1 msec, respectively. The average reaction time for the 0° mask was significantly lower than that for the 10° mask (p-value < 0.012). Likewise, the average reaction time for the -10° mask was significantly lower than that for the 0° mask (p-value < 0.009).

The graph of the slopes indicates that the presence of the mask interfered greatly with

[7] All masks within 70° of the target orientation significantly raised reaction times relative to the no-mask condition, p-value < 0.034

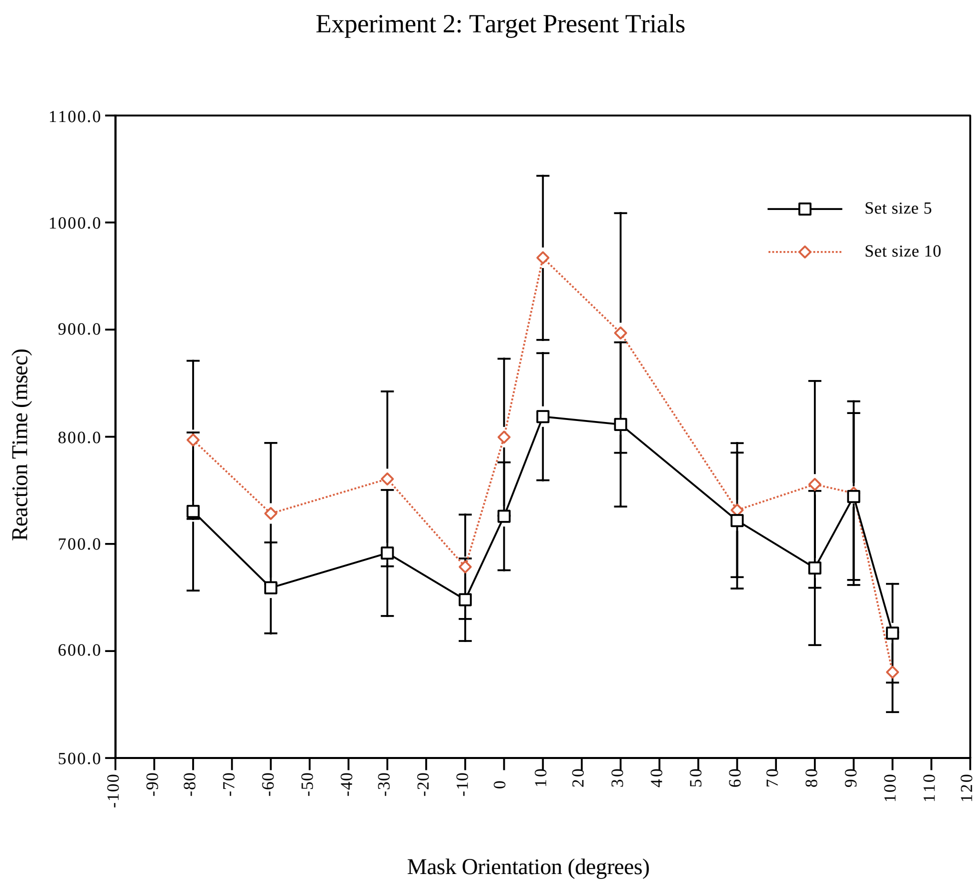

Figure 17: Target present results of Experiment 2: The average reaction times for both set size 5 and 10 conditions are plotted against the mask orientation. 100° represents the no-mask condition.

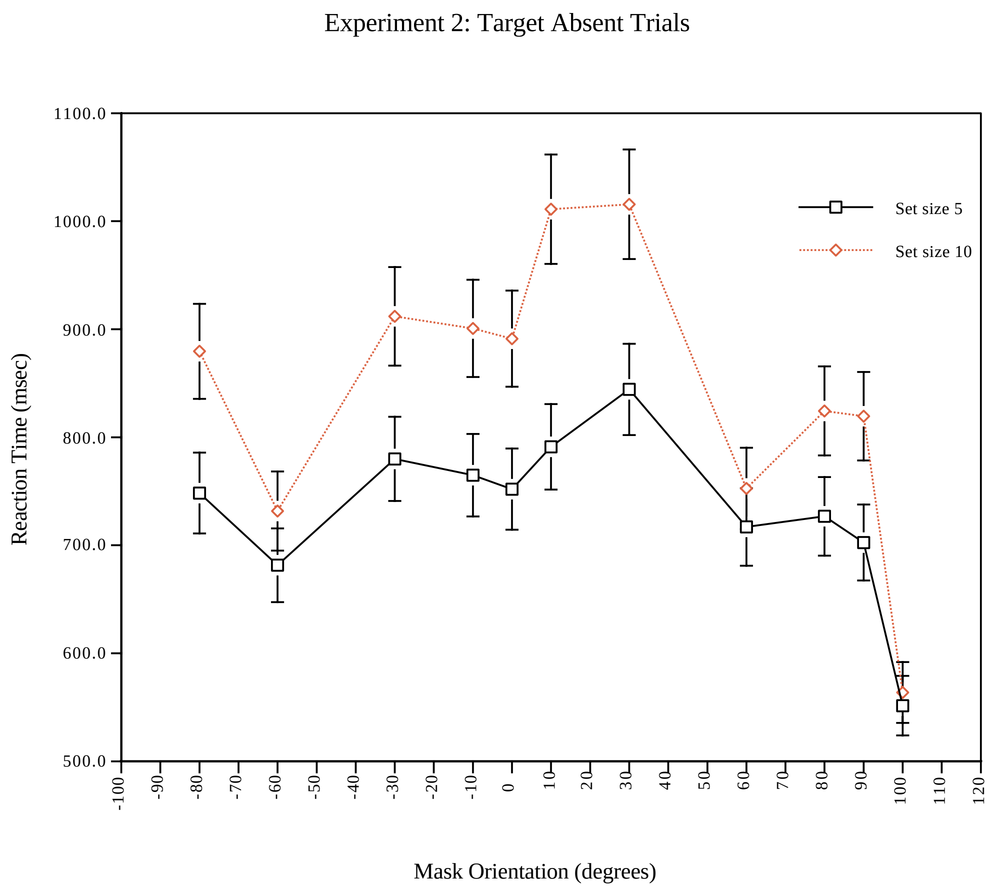

Figure 18: Target absent results for Experiment 2: These results show the same pattern as the target present results.

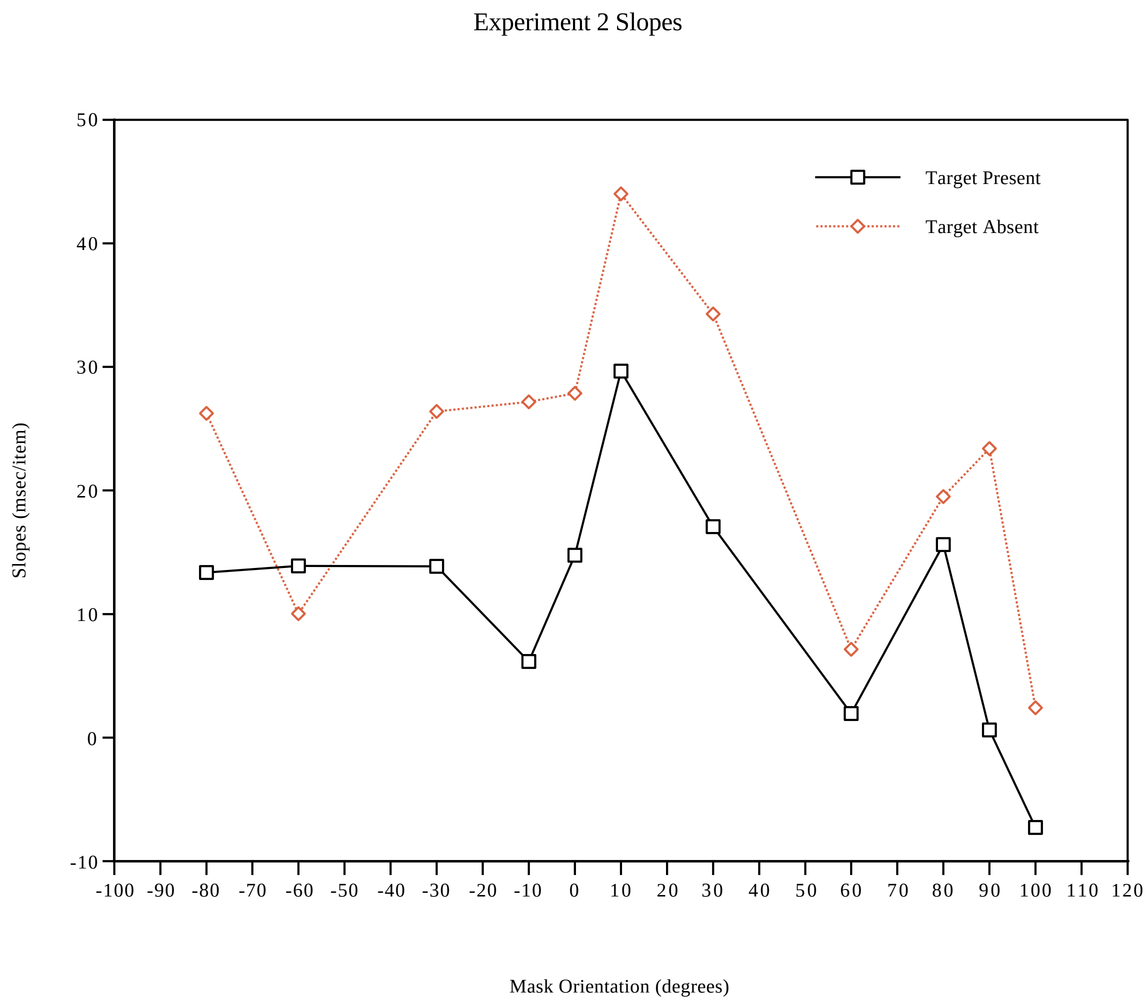

Figure 19: Graphs of slopes for Experiment 2 results: The magnitude of the slopes indicates that the mask greatly interfered with guidance to the target.

guidance to the target. The 10° mask created the most interference, as evidenced by the highest slope: 29.7 (target present), 44.0 (target absent). As in Experiment 1, there is no evidence for a speed-accuracy trade-off. Those subjects making more efficient searches do not make more errors.

4.1 Discussion

By using a larger number of orientations in Experiment 2 than in Experiment 1, we were able to create a more complete tuning curve. In contrast to predictions, the results are similar to those for standard masking experiments.

In contrast to Experiment 1, the 0° mask interferes with the search task significantly less than two right-tilted masks, 10° and 30°. One explanation for this effect is that the 0° mask acts as a reference for determining when the target is present or absent. The target is always tilted to the right of the mask, the distractors are always tilted to the left of it. To find the target, the subjects may have simply looked for an item tilted to the right of the mask, an easy task that could have lowered reaction times for the 0° mask condition. Because there was no mask between the target and distractor orientations, this condition was not present in Experiment 1.

As in Experiment 1, a facilitation effect, not detected in standard masking experiments, is apparent. When the mask was at the same orientation as the distractors (-10°), the average reaction time significantly dropped from that of the 0° and 10° masks. If the masking effect was dependent on solely the difference in orientation between the mask and the target, then the tuning curve of the results would have been symmetrical. For instance, the average reaction time for the 30° mask would have been the same as for the -10° mask (both 20° from the target orientation). The average reaction time for the -10° mask is significantly less than it is for the 30° mask ($p < 0.013$).

Furthermore, the tuning curve for Experiment 2 is broader than what would be expected in standard masking. Except for the drop in reaction time at -10°, the reaction times for all

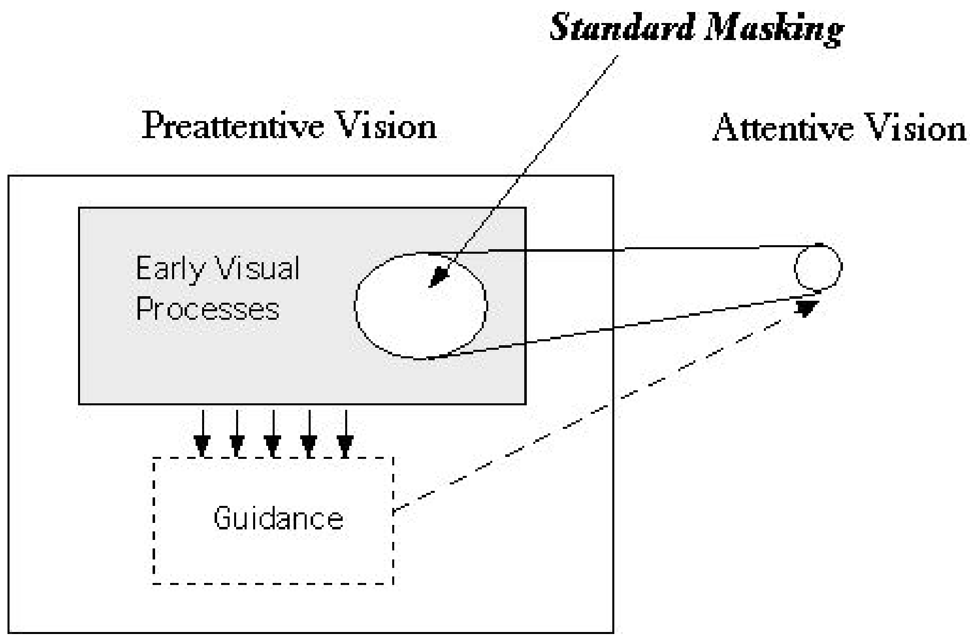

Figure 20: A highlighted flow chart of the visual process. Perhaps the subset of early vision that deals with unattended stimuli (denoted by the gray-shaded area) has different tuning curves from the subset that deals with attended stimuli.

mask orientations within 70° of the target orientation were significantly greater than that for the no-mask condition.

Similarly to Experiment 1, the magnitude of the slopes between set size 5 and set size 10 indicate that the presence of the mask greatly interfered with guidance to the target.

5 General Discussion

The results from Experiment 1 and 2 do not reflect categorization of orientations. The tuning curves of the results, apart from facilitation and broadness, resemble standard masking tuning curves. One explanation of these results could be that we were simply studying the effects of standard masking. This explanation, however, does not adequately corroborate the results because standard masking tuning curves are much more finely-tuned than the broad tuning curves we found. Furthermore, adding the masks drastically changed the slopes of the reaction times between set size 5 and set size 10. Because slopes are a measure of how quickly the visual system was able to guide attention to the target amongst a certain number of distractors, then the presence of the grating either affected the guidance mechanism or its input from early visual processes, not the areas that are studied by standard masking experiments.

But the Wolfe *et al.* data[9] clearly suggests that categories play a role in preattentive guidance for orientation. Hence, perhaps the presence of the grating affected not preattentive guidance, but the subset of early vision outside of attention[8] (Fig. 20). This possibility is extremely interesting. Standard masking experiments deal with the attentional area of early vision. The results of these experiments suggest that the tuning curves for the early visual processes dealing with attended stimuli are finely-tuned. From these results, however, scientists believed that the tuning curves for all neurons during early visual processes are finely-tuned. Our results, in contrast, suggest that the tuning curves for these neurons are broadly-tuned.

These results indicate an interesting future for the psychophysics of both preattentive guidance and early visual processing of unattended stimuli. To determine if standard masking is, in fact, at play during the visual search tasks, a control experiment is necessary. To minimize any preattentive guidance (and hence focus on attentional effects) it would differ from the two presented experiments in that the set size would one and the location of the item would be the same throughout the experiment. Another pathway of research could attempt to minimize the effect of the distractor orientation categories in the search. One possible experiment would be setting the target and distractors in the same orientation category. Furthermore, we could vary the size of the blank disks within which we placed the search items to determine the receptive fields of guidance mechanisms. The spatial frequency of the mask and items could be varied to determine if the preattentive guidance mechanisms are defined by spatial frequency. By varying how long the mask was presented during a trial, we could measure the time course of preattentive guidance. Finally, we could utilize variations

[8]The attentional subset of early vision is studied by standard masking experiments.

of the presented experiments to more fully map the tuning curves of early visual processing of unattended stimuli.

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A Experiment 1 Results

Mask Orientation	Set Size 5	Set Size 10	Standard Error (5)	Standard Error (10)
-45°	934.8 ms	1079.2 ms	90.3 ms	127.9 ms
0°	804.2 ms	942.0 ms	27.8 ms	56.5 ms
45°	892.9 ms	1145.3 ms	69.1 ms	124.5 ms
90°	807.7 ms	847.2 ms	91.1 ms	74.9 ms
no-mask	636.4 ms	663.7 ms	53.3 ms	24.1 ms

Table 1: Table of Target Present Results for Experiment 1. The averages for set size 5 and 10 are shown along with the standard error rates.

Mask Orientation	Set Size 5	Set Size 10	Standard Error (5)	Standard Error (10)
-45°	1164.4 ms	1597.7 ms	102.4 ms	214.1 ms
0°	1194.9 ms	1663.9 ms	98.2 ms	201.2 ms
45°	1119.1 ms	1580.1 ms	132.0 ms	263.6 ms
90°	991.2 ms	1292.6 ms	73.4 ms	145.8 ms
no-mask	692.6 ms	787.6 ms	42.1 ms	70.0 ms

Table 2: Table of Target Absent Results for Experiment 1. The averages for set size 5 and 10 are shown along with the standard error rates.

B Experiment 2 Results

Mask Orientation	Set Size 5	Set Size 10	Standard Error (5)	Standard Error (10)
-80°	760.6 ms	817.0 ms	144.0 ms	144.4 ms
-60°	665.1 ms	775.7 ms	72.7 ms	115.5 ms
-30°	721.3 ms	771.2 ms	92.9 ms	144.1 ms
-10°	631.5 ms	687.4 ms	50.4 ms	79.3 ms
0°	709.5 ms	763.3 ms	74.0 ms	97.6 ms
10°	759.8 ms	963.7 ms	89.5 ms	126.0 ms
30°	817.8 ms	952.3 ms	136.8 ms	220.1 ms
60°	721.5 ms	736.6 ms	119.7 ms	114.9 ms
80°	741.9 ms	820.9 ms	137.9 ms	186.5 ms
90°	732.8 ms	783.3 ms	126.5 ms	154.4 ms
100°	624.1 ms	583.8 ms	80.2 ms	67.3 ms

Table 3: Table of Target Present Results for Experiment 2. The averages for set size 5 and 10 are shown along with the standard error rates.

Mask Orientation	Set Size 5	Set Size 10	Standard Error (5)	Standard Error (10)
-80°	818.4 ms	1007.0 ms	140.9 ms	247.2 ms
-60°	695.2 ms	741.6 ms	68.1 ms	80.0 ms
-30°	796.8 ms	984.1 ms	110.1 ms	213.7 ms
-10°	799.2 ms	904.6 ms	94.5 ms	146.6 ms
0°	706.0 ms	842.8 ms	73.6 ms	111.9 ms
10°	762.7 ms	974.0 ms	71.9 ms	127.5 ms
30°	924.7 ms	1158.1 ms	242.5 ms	393.9 ms
60°	722.2 ms	701.1 ms	94.9 ms	100.5 ms
80°	771.2 ms	871.4 ms	128.6 ms	258.3 ms
90°	763.7 ms	861.3 ms	161.5 ms	249.4 ms
100°	551.1 ms	570.6 ms	43.6 ms	61.3 ms

Table 4: Table of Target Absent Results for Experiment 2. The averages for set size 5 and 10 are shown along with the standard error rates.