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Project Director(s)  G. M. Corso  GTRC/XXX

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☐ Classified Material Certificate

☐ Other

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UNCLASSIFIED - INFORMATION DISPLAYS STUDY
Human performance and visual displays

Final Report

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Prepared for:

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Abstract

Three experiments investigating search field density, type of search field and type of probe item were conducted. In Experiment 1 subjects were required to rate the complexity of a visual search field. The results suggest that rated complexity is not a function of search field density but is a function of the number of unique items in the search field. Experiment 2 was concerned with the relation between the type of probe and the type of search field. The data analysis showed an unexpected interaction between type of search field and search field density, such that at low densities the most complex search field resulted in the best performance, while the least complex search field resulted in the poorest performance. For high search field densities this result was reversed. This would suggest a trade-off between search field density by number of search field codes. Experiment 3 investigated the same variables as the Experiment 2 with the additional measure of latency. The findings of Experiment 3 suggest that multicode search fields are encoded at a time per item rate that is slower than a single code search field, but that the testing cycle for the multicode search field is faster than the single code search field. Regression equations, that can be used to estimate performance as search field density and the number of codes change, are provided.
Introduction

This report details three experiments concerned with the development of a metric which could be used to evaluate the relative effectiveness of visual display coding. The intent of the project was to provide information to the display designer which would be useful as a guide to the maximum amount of information that should be presented on a visual display. If the amount of information exceeds that limiting value, performance would begin to deteriorate. The display coding variables that were of concern throughout this research project were display load (the number of items presented on the display), code load (the number of codes presented on the display) and the correspondence between target information (what was being searched for) and field information (what was being searched).

Background

Earlier experimentation into visual display coding has concentrated on the use of specific types of codes, such as letters, digits, shapes and colors (Christ, 1975; Christ and Corso, 1983; Tullis, 1981) in both redundant (Najjar, Patterson & Corso, 1982) and non-redundant configurations. Much of the current research into visual display coding has concentrated on pictorial displays and the use of high technology devices to present information.

Most of the earlier research concentrated on the use of the information metric to predict human performance (Teichner & Mocharnuk, 1979) or the non-information metric, display density, which could be converted to $H_D$, an information metric (Briggs, Johnsen, & Shinar, 1974). Generally, these studies demonstrated a rather good relation between display density and performance for visual search tasks. However, the number of items displayed generally was rather small, and no consideration was given to either the number of codes being used or to the number of elements that were used to construct an information item. For example, in the Christ and Corso studies, the information item consisted of a single element, no multiple element items were ever displayed. The subject was required to identify the location of the digit 6 or the letter A. While there is no denying the usefulness of these types of studies, current display configurations present many display elements per information item in many different types of codes within high density displays. The overall intent of this research project was to begin to investigate the relation between very complex display formats and human performance. The ultimate goal is to develop a metric that could be used to predict human performance.

Three experiments were conducted in this phase of the research project. The first experiment was concerned with
rated complexity as a function of density and the number of different items presented on the visual display.

The intent of this experiment was to determine if it is the number of items displayed or the number of different items displayed which contribute to perceived complexity. No performance measures were obtained for this experiment.

The second experiment was concerned with search field density and number of codes on rated complexity and accuracy in a visual search and locate task. The intent of this experiment was to determine the relation between search field density, the search field format and accuracy.

The third experiment was concerned with performance as measured by search latency and the signal detection measures of d’ and beta. The intent of this experiment was to generate regression formulas that could be used to estimate latency performance.
Experiment I

Subjects

Subjects were 20 undergraduate students enrolled in Psychology classes at Georgia Tech. The students were given extra-credit towards their Psychology course grade.

Stimuli

The stimuli for this experiment consisted of displays of two-digit numbers presented by means of 35 mm. slides and front projected. The displays were positive contrast (black on white). There were four display densities used in this experiment: 16, 32, 48, 64 (two-digit) numbers. The items in the display were organized in a row and column (matrix) format. For example, density 16 had 4 rows and 4 columns of elements; 32 had 4 rows and 8 columns; 48 had 6 rows and 8 columns; and 64 had 8 rows and 8 columns. Within each density there were three types of displays presented. Type 1, in which all the numbers on the display were different; type 2, in which all of the numbers on the display were the same two-digit number; and type 3, in which all the numbers were the same two-digit number (as in type 2) but the displayed number contained two identical digits (e.g., 11, 22 or 33.

Procedure

The subjects were seated in a large room and the displays were front-projected onto a screen. Each display subtended an visual angle of approximately 13 x 13, with each two digit number subtending approximately 30'' x 30''. The total extent of each display was the same across different densities. The subjects were instructed that they would be presented with a series of displays and that for each display they were to rate the complexity of each slide on a scale of 1 - 7, with 1 being least complex and 7 being most complex. Each display was presented for approximately 3 secs. followed by an interval in which the subjects could mark their response sheets. There were 26 displays per density (total = 96). Displays of different density and type were presented in random order.

Results and Discussion

The results of this experiment are presented in Figure 1. This figure clearly shows an increase in rated complexity as display density increases. However, it is also apparent that this increase in rated complexity occurs only for one of the three functions presented in this figure. For the other two functions display density has no influence on rated complexity. These latter two functions are for the situation where all the two digit numbers are identical, and
Figure 1. Rated Complexity as a function of display density.
where both digits of the two digit numbers are the same. Consequently the significant variable, within this experiment, is the number of different elements displayed and not the total number of displayed elements. As a result, it would appear that many if not all of the studies investigating display density have confounded display density with the number of different elements displayed. That is to say, differences in rated complexity which result from differences in display load, could just as well be the result of an increasing number of different elements being displayed. Whether or not this finding also applies to performance measures may be difficult, if not impossible, to determine. However, on logical grounds it could be argued that such a confound could contribute to changes in performance. For example, it would appear that increasing the number of noise elements displayed from four to twelve should have very little effect on performance as long as all the noise elements were the same. However, as one begins to increase the number of different elements within the display from four to twelve, performance should decrease.

By redrawing Figure 1 so that the parameter is display size, and the X-axis is the number of different elements, further support for our argument can be obtained. In Figure 2, rated complexity is a function of the number of different elements in the display with display density as the parameter. Two rather obvious observations can be drawn concerning this figure. First the functions relating rated complexity and number of different elements are parallel. This observation would suggest that display density and the number of different elements are influencing the same psychological processes. The second observation is that the magnitude of the differences between the different display densities is minor. The net effect is that it is the number of different display elements and not display density that contributes to rated complexity.

Because the rating data are based on an ordinal scale, no further statistical analyses were performed.
Figure 2. Rated complexity as a function of the number of unique items in the display.
Stimulus Material For Experiments II and III

Experiments II and III used the same set of stimuli. The stimuli will be described first followed by a description of specific procedures for each experiment.

Stimuli

The search fields used in the present set of studies were similar to a generic JTIDS format. Each search field was composed of a number of elements. Each individual element of the display was composed of a circle representing a specific aircraft together with a set of coded information. To maximize the usefulness of the stimuli, the information components were designed to represent categorical information, heading information, altitude information and an identification label. The exact nature or definition of the information was not critical for the present study.

Two types of search fields were constructed. The first type of search field was constructed in monochrome (black on white) using a single code (i.e., numeric) for presenting the search field element components. This information included a number (1, 2, 3, or 4) inscribed within the circle and three three-digit numbers below the circle. The inscribed number was a general category code; the top three-digit number indicated heading information; the second three-digit number indicated altitude levels and the bottom number was an identification number for the aircraft/display element. The category, heading, and altitude components could assume one of four values. The occurrence of each specific value was evenly distributed in each search field. The identification number was a random three digit number which occurred only once per search field.

The second type of search field was constructed in color using multiple codes for the element components (i.e., color, shape and numeric codes). This condition contained the same information as the single code search field. In this search field, however, the categorical information was coded by filling the circle with a color rather than an inscribed number. Similarly, the heading information was coded with shape by using a line extending from the perimeter of the circle in an appropriate direction. The altitude and the identification information was coded numerically as in the single code search field.

For each search field there were three densities of search elements: 8, 16, or 32. Search elements could occur randomly in any of 77 possible locations (7 rows and 11 columns). While, the elements were randomly distributed across the search field, there was some regularity associated with the placement of elements in locations on a (invisible) matrix.
The information contained in each type of search field was consistent. That is, the two types of search fields represented two sets of identical displays with the same elements in the same locations with the same information, but with the information presented in a different coding scheme. Samples of these search fields and probe items are presented in Figures 3 through 7.

Procedure

The general procedure used in experiments II and III was a search task where subjects were required to decide whether a search field contained a specific probe item. There were several different probe items. For both Experiments, search fields and probe items were presented on a screen in front of the subjects. The screen was positioned approximately 12 ft. in front of the subjects. The search fields subtended visual angles of approximately 13 x 16 (width x height) while the visual angle of the individual elements were approximately 1 x 2 (width x height). The probe items were presented in the center of the viewing area, and appeared as they would (same size, color, etc.) on the display screen.
Figure 3. An example of the ID # probe.
Figure 4. An example of the monochrome.single code probe.
Figure 5. An example of the color/multicode probe. The black circle is a color.
Figure 6. An example of the monochrome/single code search field. Density is 16.
Figure 7. An example of the multiple code/color search field. Density is 8.
Experiment II

Subjects

Subjects were obtained from the same pool of subjects as Experiment I. They were given extra-credit for their Psychology class grade. The subjects were required to have 20-20 corrected or uncorrected vision. Subjects participated in groups of 3 to 10 per session. The total number of subjects for this experiment was 60, placed into four groups in the following manner. Group 1 consisted of 17 subjects, group 2 consisted of 18 subjects, 15 subjects in group 3, and 10 subjects in group 4.

Procedure

The subjects were presented with a probe item followed by the presentation of the search field. The subjects were instructed to decide, as quickly and accurately as possible, if the probe item was present in the search field. Subjects were to indicate their response on the response sheet. The exposure duration for the display screen was set based on a search rate of 200 ms per element in the display. This yielded exposure durations of approximately 2, 4, and 8 seconds for the display densities of 8, 16, and 32 respectively. Following the presentation of the search field the subjects were required to rate "... how complex they considered the display to be ... 1 representing the least complex and 5 representing the most complex". Again, subjects were required to mark their response on the response sheet.

The probe item could be either a complete element from the display or a single three-digit (identification) number. In the case where the probe item was an entire element from the display; i.e., a circle with three three-digit numbers, subjects were instructed that the probe element would appear in the search field as it did in the probe slide. The subjects were also instructed that various information components may be common across different elements, but that the identification number was the only unique feature of the element. In the other case, where the probe was a single three-digit identification number (ID), the subjects were instructed that the probe would be the identification number and that it would only appear in the identification number position (bottom number of the element).

There were a total of four conditions for this experiment. These conditions are presented in the following table. Both probe type and search field type were manipulated between-subjects.
Search field density was manipulated as a within-subjects variable. Search fields were blocked on density and the order of presentation for the blocks was counterbalanced. Each group of subjects was presented with a single type of probe item at three display densities with 20 trials per density for a total of 60 trials.

Results and Discussion

Accuracy data analysis. The results are presented in Figure 8. From this figure it can be seen that the percent correct was a function of the interaction between search field density and the four display-probe conditions. An analysis of variance supports this conclusion, $F(6, 114) = 7.13$, $p < .01$. Performance for low density was poorest for Condition 2, where the subject was presented with only the ID as the probe and the searched a field comprised of monochrome/single code information. Best performance occurred at the low density with where identical color/multicode items were used as probes and the search field was also comprised of the same color/multicode items, condition 3. For the high density search fields this finding was reversed. That is, the color/multicode condition resulted in the poorest performance with the best performance being associated with condition 2. For the middle level density of 16 elements, conditions 1, 3 and 4 resulted in essentially the same level of performance.

These results were totally unexpected. We had believed that accuracy would have decreased as density increased. As can be seen from Figure 8, the only time that increases in density resulted in a steady decrease in accuracy was for condition 3. In fact, accuracy increased for conditions 1, 2 and 4 as density increased from 8 to 16 items. One reason for these findings may have been due to blocking on search field density; however, by counterbalancing the order of density presentations this should have reduced any effects of order of presentation.
Figure 8. Percent correct as a function of search field density with condition as the parameter.
Signal detection analysis.
The data for percent correct was separated into percent hits and percent correct rejections for each of the four conditions. In so doing a signal detection procedure developed by Frey and Colliver (1973) could be used to investigate the responsivity and sensitivity measures. Responsivity is similar to the traditional signal detection measure of Beta, while sensitivity is similar to the signal detection measure of d'. Sensitivity can range from 0 to 1, while negative numbers associated with responsivity indicate a negative bias. The advantage of these two measures over the traditional measures is that no assumptions about the distributions needs to be made and both can still be computed even when the false alarm rate is zero. These measures are presented in the table below.

<table>
<thead>
<tr>
<th>Search Field</th>
<th>Probe</th>
<th>Density</th>
<th>Responsivity</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monochrome/ID #</td>
<td>8</td>
<td>-.56</td>
<td>.81</td>
<td></td>
</tr>
<tr>
<td>single code</td>
<td>16</td>
<td>-.59</td>
<td>.69</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>-.58</td>
<td>.73</td>
<td></td>
</tr>
<tr>
<td>Monochrome</td>
<td>8</td>
<td>-.58</td>
<td>.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>-.36</td>
<td>.78</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>-.58</td>
<td>.78</td>
<td></td>
</tr>
<tr>
<td>Color/multi ID #</td>
<td>8</td>
<td>-.56</td>
<td>.80</td>
<td></td>
</tr>
<tr>
<td>code</td>
<td>16</td>
<td>-.54</td>
<td>.87</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>-.59</td>
<td>.77</td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>8</td>
<td>-.55</td>
<td>.83</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>-.55</td>
<td>.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>-.64</td>
<td>.68</td>
<td></td>
</tr>
</tbody>
</table>

From this Table it can be seen that in general both measures were rather stable for the two types of search fields, the three types of probe items and the three levels of search field density. For all conditions there was a small negative bias.

Rating analysis.
Since the densities were blocked, the analysis associated with perceived complexity did not result in any differences between the densities. Given the nature of the experimental design these results were expected. However, we had hoped to find a difference between the rating of perceived complexity across conditions. These results did not occur, also probably due to the experimental design.
Experiment III

Subjects

Subjects were 15 undergraduate volunteers from Introductory Psychology classes. The subjects were required to have 20-20 corrected or uncorrected vision. The experiment was conducted on 2 to 4 subjects at one time. The subjects were randomly assigned to one of two groups, a group presented with the monochrome/single code condition, \((N = 7)\), or a group presented with the color/multicode condition, \((N = 8)\).

Design

Display type was manipulated as a between-subjects variable and probe type and density were manipulated as within-subjects variables.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Display Type</th>
<th>Probe Type</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Monochrome/Single Code</td>
<td>single code</td>
<td>8,16,32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>multi-code</td>
<td>8,16,32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ID number</td>
<td>8,16,32</td>
</tr>
<tr>
<td>2</td>
<td>Color/Multi-code</td>
<td>single code</td>
<td>8,16,32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>multi-code</td>
<td>8,16,32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ID number</td>
<td>8,16,32</td>
</tr>
</tbody>
</table>

Procedure

Subjects were instructed that they would be presented with a series of slide pairs. The first slide would be the probe or target item, while the second slide would be the search field. Subjects were presented with a probe item for 500 ms. followed by the presentation of the search field for 3000 ms. As in the previous study, the subjects were instructed to decide, as quickly and as accurately as possible, if the probe item was present in the search field.

The subjects were told that the probe items could be of three types and were shown examples of the probe items. In one case the probe item was an entire element from the display; i.e., a circle with three three-digit numbers and was coded in the same manner as the display. The subjects were instructed that the probe element would appear on the search field slide as it did on the probe slide. They were also informed that various information components may be common across different elements, but that the identification number was the unique feature of the element.
In the second case the probe was a complete search field element, but the element was coded differently than in the search field. For example, a probe using the color and figural codes presented for a monochrome/all numeric code search field. Again, the subjects were told that the identification number was the unique feature of the element.

In the third case, the probe was a single three digit identification number (ID). The subjects were instructed that the probe would be the identification number and that it would only appear in the identification number position (bottom number of the element).

Subjects were to respond yes or no by pressing the appropriate button with the first finger of their preferred hand. Button assignment (yes-no) was counterbalanced across subjects. Subjects were presented with three probe types each with three densities with twenty trials per density yielding a total of 180 trials. Probe type and density were presented in random order.

Results and Discussion

Latency data analysis.
The latency data were separated into hit latencies and correct rejection latencies. For the latencies associated with hits, the only significant effect was due to search field density, $F(2,26) = 60.35, p < .01$. These results are presented in Figure 9. As the search field density increased, latency also increased. No other main effects or interactions were observed to be significant.

For the correct rejection latency data, search field density was significant, $F(2,26) = 245.35, p < .01$. As search field density increased so did the latency to respond. Also observed to be significant was the interaction between search field density and type of search field, $F(4,52) = 4.18, p < .01$ and the interaction between the type of search field, the type of probe and search field density, $F(4,52) = 7.48, p < .01$, this interaction is presented in Figure 10.

Accuracy data analysis.
In a similar manner, the percentage of hits and correct rejections were also subjected to an analysis of variance. For the percent hits, all main effects and interactions were significant as shown in the following table:
Figure 9. Hit latency as a function of search field density.
Figure 10. Correct rejection latency as a function of search field density with search field type and probe type as parameters.
The interaction between search field, density and probe type is presented in Figure 11. From this figure it can be seen that, in general, the multiple code conditions resulted in fewer hits than the single code condition. This would suggest that not only does search field density have an effect on accuracy but that the number of codes used in the search field also plays a role in performance. This finding would also seem to support the finding of the first experiment, which suggested that it is the total number of different items being searched through that contributes to performance decrements, and not just the total number of items. As a result any change in a search field that keeps the total number of displayed items constant and adds different codes to those items, thereby increasing the number of different items will result in a performance decrement.

For the percent correct rejections all main effects and interactions were significant except for the main effect of type of search field. These results are presented in the following table:

The interaction between search field, density and probe type is presented in Figure 12. In this figure it can be seen that the subjects performed at a rather high level even at the greatest search field density. In fact for almost all conditions performance leveled off at a search field density of 16.
Figure 11. Percent hits as a function of search field density with search field type and probe type as parameters.
Figure 12. Percent correct rejections as a function of search field density with search field type and probe type as parameters.
Signal detection analysis. A conversion of the data to the signal detection parameters of responsivity and sensitivity are presented in the Table below. Using this conversion sensitivity is a measure of the discriminability similar to d’ except that this measure ranges from 0 to 1. Responsivity is similar to Beta with negative numbers indicating a bias to say no. It must be noted that these data were derived from group percentages and not individual subjects.

<table>
<thead>
<tr>
<th>Search Field</th>
<th>Probe</th>
<th>Density</th>
<th>Responsivity</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monochrome</td>
<td>ID #</td>
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<td>-.52</td>
<td>.88</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>32</td>
<td>-.72</td>
<td>.39</td>
</tr>
<tr>
<td>Single code</td>
<td>8</td>
<td>-.61</td>
<td>.63</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>-.61</td>
<td>.67</td>
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<td></td>
<td>32</td>
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<td>.66</td>
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</tr>
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<td></td>
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<td>-.63</td>
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<td></td>
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</table>

From these data it appears that both responsivity and sensitivity were relatively stable across the two types of search fields, the three densities and the three different probe types. Moreover they appear to be quite similar in magnitude and direction to the same measures from Experiment 2.
Discussion

The latency data and corresponding accuracy data can be described by a model for memory search proposed by Briggs and his colleagues (Briggs, Thomason & Hagman, 1978). The model, presented in Figure 13, is an information flow system with a series of tests. In this particular case two tests are proposed, with each test being concerned with the presence or absence of the probe item in the search field. At test 1, if the probe item is found in the search field the test is terminated and a "yes" response is emitted. If the probe item is not found, a second test occurs. If the probe item is not found a "no" response is emitted. A "no" response, given the presentation of a search field where the probe item is not present, is a correct rejection. A "yes" response given the presentation of a search field where the probe item is present, is a hit. This model would suggest that correct rejection latencies should take longer than the latencies associated with a hit, which they did, because of an additional test. Furthermore, because there is an additional test, the percentage of correct rejections should be greater than the percentage of hits, which they were.

Taking this model further, let us assume that the latency associated with a hit is a function of the time to encode the search field display, the time to test the probe item against the search field and the time to decode a response. Further, let us assume that the latency associated with a correct rejection is made up of the same subprocess as a hit plus an additional test. If we assume that the time to test is the same for both the first and second tests then the differences between the latencies associated with the correct rejection and the hits is due to the second test. Furthermore, by subtracting this difference from the hit latency, the difference reflects the time to encode the search field and the time to decode the response. For example, the correct rejection and hit latency associated with a search field density of 8 in condition 1 where the probe item was the ID were 3198 and 2129 respectively. The difference between these two values is 1069. This number reflects the time to test all items against the probe. Subtracting 1069 from 2129 results in a value of 1060. This value reflects the amount of time to encode the search field and to decode a response. If the test latency and encoding latencies are divided by the search field density a rather unique pattern of results occurs. The actual results for these data using the previously described procedure are presented below for each search field density and probe item.
Figure 13. Model of visual search performance

Probe in search field  hit  Guesses  miss
Probe not in search field  false alarm  correct rejection
The unique finding from this procedure is that the multiple coded search field takes longer to encode than the monochrome search field, but that the test cycle is shorter for the multiple coded search field than for the monochrome search field. Two other surprising findings can also be observed from the plot of these data, presented in Figures 14 and 15. For the time per item for both the encoding and the testing processes, as search field density increases, the time per item decreases. The decrease appears to be much greater for the encoding/decoding process than for the testing process. A regression of these two processes collapsed over probe type results in the following equations:

For the monochrome search field,

(1) \[ \text{Time/item} = \text{Density} \times (-1.7) + 140.6 \] for testing
(2) \[ \text{Time/item} = \text{Density} \times (-2.6) + 126.9 \] for encoding

Consequently a substitution for a density of 48 should result in a time of 58.4 ms per item for each test or a
Figure 14. Encoding time per item as a function of search field density with search field type and probe type as parameters.
Figure 15. Testing time per item as a function of search field density with search field type and probe type as parameters.
total of 2803 ms for testing a 48 item monochrome/single code search field. The time to encode such a search field would be 100.8 ms for the total search field. The expected latency associated with a hit for this size search field would be 2900 msec. However, given that the time per item to encode a 48 item search field is estimated to be about 2.1 ms we could be assured of a very high error rate that is due, not to the test cycle but to a failure to encode the search field items.

In a similar manner the regression equations for the multicode search field are:

(3) Time/item = Density (-1.2) + 99.6 for testing
(4) Time/item = Density (-3.6) + 183.8 for encoding

Once again substituting a search field density of 48 items the total time associated with a hit would be 2832 ms. However, as before the probability of a hit occurring would be rather small since the encoding time per item would be 1.4 ms, a rather small amount of time to encode each item.
General Conclusions

The three experiments conducted for this project have suggested some rather unique findings.

1. In most visual search studies, display density is confounded with the number of unique items. It appears that it is the uniqueness of the items and not the total number of items that is important for ratings of complexity and maybe for performance. Obviously more research into this questions needs to be performed.

2. The pattern of correct rejections and hits along with their associated latencies suggests a model of human performance that has been associated with memory search. This memory search model appears to have implications for models of visual search.

3. Multicoded search displays appear to require more time to encode than monochrome/single search displays but once encoded, they appear to be tested at a faster time per item rate. It appears that additional investigations into this conclusion is required.

4. It would appear that a 48 character search field would result in a very limited time per item test, and that maybe this number of characters would be the limit for any search field. Additional studies should be performed to identify the maximum number of characters that could be used in any search field.

While these conclusions are exciting, it should be pointed out that other tasks should be investigated within this framework. It remains to be seen whether these findings would hold for different types of tasks.
References


