# A Study of Inspector's Behavior for Stopping Strategies as Multiple-Target Search

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*Abstract:* - The main purposes of this research were to study inspector's behaviours for stopping strategies and performance to detect defects as multiple-target search. Visual task was computer simulated search tasks and defect was indicated in English character X with the background characters of A, K, M, N, V, W, Y and Z filled up to 50% of searching area in each screen. Ten subjects were students randomly chosen from King Mongkut's University of Technology Thonburi (KMUTT) with 20/20 vision test. They were asked to perform inspection task to pass for pilot study before running the experiment. The experiment was consisted of visual search task and look for defects, which composed of one, two, three and four defects existed randomly. Preliminary information was provided to subjects before running the experiment. They were asked to perform the experiment by searching and detecting the defects using mouse to choose for them without time limits. Subjects could decide to stop searching at anytime by themselves and data of mean search time, mean stooping time, and number of defects detected would be recorded. The results were shown that the inspector's behaviours were affected by the patterns of time spent in searching and stopping. Moreover, subject could detect defect for 100 percent on single defect. This could be concluded that inspector's behaviour was affected by the number of defects, which showed significantly different at the level of 0.05, and mean stopping time and percent defect detected at the level of 0.01.

*Key-Words:* - Visual Inspection / Inspector Behavior / Mean Search Time / Mean Stopping Time

## 1 Introduction

At the present, there are many competitive to the market to keep customer's satisfaction. This would enforce company to have successful inspection on products. The best way to do this is inspection to detect defects on product before reaching and quality assurance to customer [1]. In this situation, how do human observers decide the stopping time? This question is really important in the research issues related to visual search performance. As mentioned in many researches, visual inspection has been composed of two primary functions: visual search and decision making [2]. Visual search is inspector looked for defect interested while decision making is inspector who has to make decision to accept or reject the product before determining a stopping time. Therefore, this would be indicated that if inspector does not have the experience, the bad product could be passed to external customers. This inspection becomes the important step in manufacturing industries [3]. Product inspection is one dimension of a comprehensive quality assurance program. While there are many forms of inspection, visual inspection is predominant. Humans are regularly assigned to visual inspection tasks even though it has long been established that their performance is not entirely satisfactory [4]. These functions are the main determinants of inspection performance and must be executed reliably for inspection to be successful.

This is largely due to the fact that human visual search behaviour tends to be less performance, which leads to incomplete visual coverage. However, the superior decision making ability of humans, along with their inherent flexibility, make them desirable inspectors. Thus,

due to these and other shortcomings of automation [5, 6], methods to improve the search behaviour of inspectors are sought and interested in the decision mechanism for determining a stopping time.

However, those models were limited to the visual search task for finding one target. In this research, the optimal stopping time model of the one-target search is extended to that of a multiple-target search. Additionally, a visual search program experiment was performed in order to investigate, which optimal stopping time usage strategy is most effective.

# 2. METHODOLOGY

## 2.1 Visual Task

Visual inspection task was simulated search tasks indicated that English character X was defect with the background characters of A, K, M, N, V, W, Y and Z, which was filled up to 50% of searching area in search screen. The defect and background characters were times new roman front size and 12 point bold.

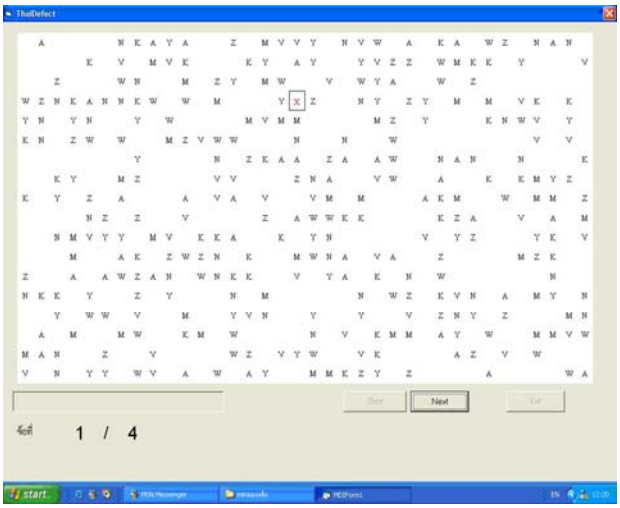


Fig.1. Examples of visual inspection task for single defect.

## 2.2 Stimulus Material

The experiment was run by using computer Pentium IV, 1.5 GHz ram 512 MB with 17 inch monitor, standard keyboard, and mouse. The example of screen capture for single defect was showed in Fig.1.

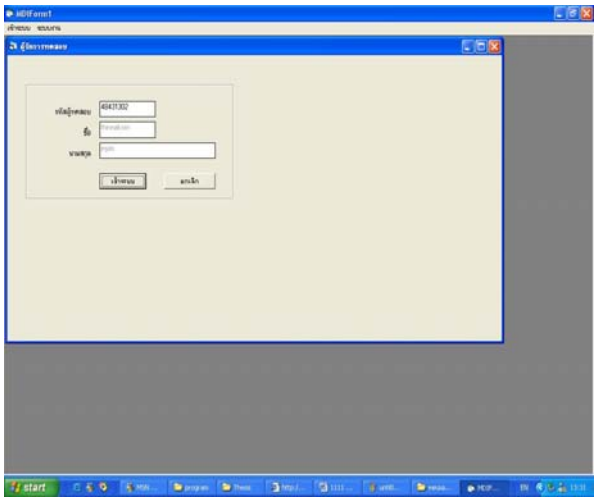

Fig.2. Sample of defect setup display

## 2.3 Subject

Ten subjects were student randomly chosen from King Mongkut's University of Technology Thonburi (KMUTT) with 20/20 vision test. All subjects were asked to test for 20 preliminary trials and only who pass at least 60 percent of defect detected would be considered as pilot study section.

## 2.4 Pilot Study

Twenty subjects were randomly chosen from KMUTT with 20/20 vision test. All subjects were asked to test for 20 trials and only who pass at least 60 percent of defect detected were considered to perform the experiment. All data of inspector's performance was recorded.

## 2.5 Experimental Design

The experiment was consisted of one, two, three and four defects, which were totally equal to 100 points. All subjects were asked to perform experiment of 40 trials as showed in Table 1.

## 2.6 Procedure

All 10 subjects took part in visual inspection tasks this experiment. Basic information was provided to subjects before running the experiment. The subjects were running the experiment by searching and detecting the defects without time limit. There were 40 trials in experiment.

Table 1. Experimental design

| Pattern | Defect types | Trials of task | Backgrounds | Total defects |
|---|---|---|---|---|
| 1 | 1 | 10 | 50% | 10 |
| 2 | 2 | 10 | 50% | 20 |
| 3 | 3 | 10 | 50% | 30 |
| 4 | 4 | 10 | 50% | 40 |
| **Total** | **-** | **40** | **-** | **100** |

### 2.7 Data Collection

Data was collected on performance measure, which is search time and mean search time, stopping time and mean stopping time, and percent defects detected and defect missed of inspector performance recorded in computer program.

## 3. RESULTS

### 3.1 Mean Search Time

The result of mean search time on multiple target searches was showed significantly different at the level of 0.05 for all defects as shown in Table 2. The least significant difference (LSD) analysis for each mean search time for all defects was analyzed and showed in Table 3. The result was indicated that one defect type was significantly different from the others with mean search time of 27.10 second as showed in Fig. 3.

Table 2. ANOVA on mean search time

| Source | Df | Sum of Squares | Mean Square | F | p-value |
|---|---|---|---|---|---|
| Factor | 3 | 400.2 | 133.4 | 2.92 | 0.047 |
| Error | 36 | 1643.6 | 45.7 | | |
| Total | 39 | 2043.8 | | | |

Table 3. LSD for mean search time

| # of Defect | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **1** | | ** | ** | ** |
| **2** | | | - | - |
| **3** | | | | - |
| **4** | | | | |

**Significantly different at the level of 0.05

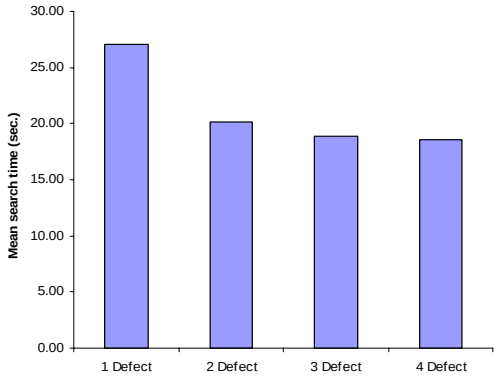


Fig.3. Comparison of mean search time for all defects

### 3.2 Mean Stopping Time

The result of mean stopping time on multiple target searches was showed significantly different at the level of 0.01 for all defects as shown in Table 4. The LSD analysis for each mean stopping time for all defects was analyzed and showed in Table 5. The result was indicated that one defect type was significantly different from the others with mean stopping time of 66.97 second, and two defects was significantly different from three as showed in Fig. 4.

Table 4. ANOVA on mean stopping time

| Source | Df | Sum of Squares | Mean Square | F | p-value |
|---|---|---|---|---|---|
| Factor | 3 | 5217.0 | 1739.0 | 20.79 | 0.000 |
| Error | 36 | 3010.7 | 83.6 | | |
| Total | 39 | 8227.7 | | | |

Table 5. LSD for mean stopping time

| # of Defect | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | | * | * | * |
| 2 | | | ** | - |
| 3 | | | | - |
| 4 | | | | |

**Significantly different at the level of 0.05
*Significantly different at the level of 0.01

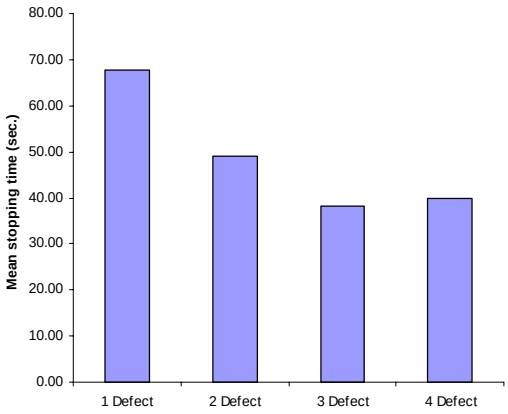


Fig.4. Comparison of mean stopping time for all defects

### 3.3 Percent Defect Detected

The result of percent defect detected on multiple target searches was showed significantly different at the level of 0.01 for all defects as shown in Table 6. The LSD analysis for percent defect detected for all type of defects was analyzed and showed in Table 7. The result was indicated that one defect type was significantly different from the others with percent defect detected of 100% as showed in Fig. 5.

Table 6. ANOVA on percent defect detected

| Source | Df | Sum of Squares | Mean Square | F | p-value |
|---|---|---|---|---|---|
| Factor | 3 | 2451.3 | 817.1 | 15.83 | 0.000 |
| Error | 36 | 1858.7 | 51.6 | | |
| Total | 39 | 4310.0 | | | |

Table 7. LSD for percent defect detected

| # of Defect | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1 | | * | * | * |
| 2 | | | - | - |
| 3 | | | | - |
| 4 | | | | |

*Significantly different at the level of 0.05


Fig.5. Comparison of percent defect detected

Table 8. Data collected for all subjects on mean search time, mean stopping time and percent defect detected for all types of defects

| | 1 Defect | | | | 2 Defect | | | | 3 Defect | | | | 4 Defect | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean search time (sec.)** | **Mean stopping time (sec.)** | **Defect detected** | **% defect** | **Mean search time (sec.)** | **Mean stopping time (sec.)** | **Defect detected** | **% defect** | **Mean search time (sec.)** | **Mean stopping time (sec.)** | **Defect detected** | **% defect** | **Mean search time (sec.)** | **Mean stopping time (sec.)** | **Defect detected** | **% defect** |
| 1 | 17.00 | 71.20 | 10 | 100 | 10.35 | 54.80 | 20 | 100% | 8.73 | 26.00 | 28 | 93% | 7.07 | 29.50 | 35 | 88% |
| 2 | 18.40 | 51.30 | 10 | 100% | 15.65 | 50.10 | 19 | 95% | 9.25 | 28.40 | 26 | 87% | 11.72 | 26.30 | 36 | 90% |
| 3 | 22.60 | 58.90 | 10 | 100% | 21.20 | 55.60 | 17 | 85% | 15.60 | 31.80 | 27 | 90% | 13.72 | 39.80 | 34 | 85% |
| 4 | 37.00 | 60.40 | 10 | 100% | 25.15 | 52.00 | 16 | 80% | 24.93 | 38.60 | 26 | 87% | 22.04 | 32.00 | 32 | 80% |
| 5 | 32.60 | 70.10 | 10 | 100% | 16.20 | 59.90 | 14 | 70% | 26.93 | 49.10 | 20 | 67% | 23.26 | 59.20 | 30 | 75% |
| 6 | 29.60 | 67.60 | 10 | 100% | 16.35 | 44.50 | 15 | 75% | 16.58 | 48.50 | 22 | 73% | 24.20 | 53.40 | 28 | 70% |
| 7 | 19.50 | 71.40 | 10 | 100% | 17.10 | 43.60 | 16 | 80% | 19.12 | 27.80 | 28 | 93% | 21.54 | 34.70 | 31 | 78% |
| 8 | 24.10 | 75.80 | 10 | 100% | 24.30 | 30.40 | 18 | 90% | 26.30 | 42.50 | 26 | 87% | 22.65 | 42.20 | 29 | 73% |
| 9 | 34.20 | 65.40 | 10 | 100% | 26.80 | 52.80 | 16 | 80% | 24.12 | 52.70 | 24 | 80% | 23.19 | 42.40 | 34 | 85% |
| 10 | 36.00 | 77.60 | 10 | 100% | 28.15 | 48.00 | 16 | 80% | 27.58 | 36.90 | 24 | 80% | 24.80 | 39.10 | 29 | 73% |

# 4. DISCUSSION AND CONCLUSION

As the results, it was indicated that inspector behaviour was affected by the type of defects, which was one defect type for this research for mean search time, mean stopping time and percent defect detected. The results were shown significantly different at the level of 0.05 for mean search time and at the level of 0.01 for mean stopping time and percent defect detected. These results were supported by the study of human stopping strategies in multiple-target search of Seung-Kweon Hong [7]. It revealed that the performance of the self-stopping strategy was performance inspectors higher, but performance search time it low.

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