VIGILANCE PROBLEMS IN ORBITER PROCESSING

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ABSTRACT

A pilot experiment was done to determine what factors influence potential performance errors related to vigilance in Orbiter processing activities. The selected activities include post flight inspection for burned gap filler material and pre roll out inspection for tile processing shim material. It was determined that the primary factors related to performance decrement were the color of the target and the difficulty of the target presentation.

INTRODUCTION

The high quality of work performed in most processing activities and the relatively low rate of occurrence of quality incidents paradoxically can be expected to lead to a particular type of human factors problem in tasks where human operators or inspectors are required to detect the occurrence of "low probability of occurrence" events. It is known that in tasks of this nature there is a "high probability" of failing to detect low probability of occurrence "events." The phenomena occurs in most all types of tasks where detection of low probability events is required and occurs despite the degree of training, skill, and alertness of the inspector or the apparent obviousness of the event to a person not involved in the inspection.

This problem has been demonstrated in numerous tasks such as air defense radar monitoring, microscopic inspection of tissue for cancer growth, and a variety of industrial type inspections for defects has been demonstrated. This problem is frequently called "the vigilance problem or phenomena" in the literature.

Examples of Orbiter processing tasks which could be expected to experience the problem because of the task structure and the relatively low probability of occurrence of events include:

- STR system post flight inspections
- TPS post flight and roll out inspections
- ECL radiator inspection prior to roll out
- STR system aft closeout inspection for removal of access equipment
- INS, COM, EPD electrical systems connection inspection

All of the above tasks involve visual inspection and the need to recognize the presence of a low probability of occurrence condition. Although the condition or event needed to be detected may seem "obvious" (e.g., unconnected electrical connectors, beam in aft, indentation in tile, etc.) research in the problem area suggests that error rates in the neighborhood of a 1 to 10 chance of failure to detect may occur when there is a probability of event occurrence of 1 in 100. Probability of inspection task failures would be expected to increase as the probability of occurrence decreases.

This paper presents the results of a study designed to demonstrate the potential for vigilance type problems in selected Orbiter processing activities and to determine the processing task characteristics influencing the magnitude of the vigilance decrement.

ORBITER PROCESSING TASKS

An experimental task simulating two Orbiter processing activities was designed for use in this study. The Orbiter processing tasks simulated in this study were:

- Post flight inspection of TPS (Thermal Protection System) tile gaps for charred gap filler material.
- Pre OPF (Orbiter Processing Facility) "roll out" inspection of TPS tile gaps for presence of processing shims.

The reasons for selecting these particular tasks included:

- The tasks are easily learned so that any vigilance decrement observed in the performance of the tasks should not be confounded with learning effects.
- The tasks do involve low probability of occurrence events. Given 25,000 or more tiles on the vehicle (depending on the particular vehicle being inspected) there are relatively few gaps in which shims are left after processing or in which burned gap filler is found.
- The tasks are the type of inspection task which the ample literature on vigilance suggests would be candidates for a vigilance effect.

THE EXPERIMENTAL TASK

The inspections described above are done by the technicians who work under the vehicle and look directly up at the tile gaps. The viewing distance in these inspection situations varies from about one foot to five feet. To simulate this situation, subjects in the experimental situation were required to look at successive iterations of the pattern shown in Figure 1.

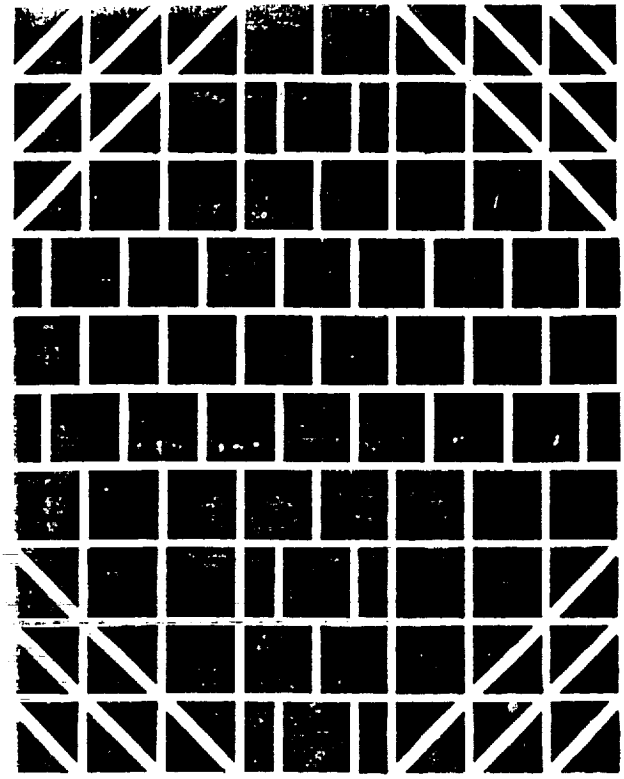

Figure 1: Simulated Tile Pattern Configuration

This pattern, which is similar to the tile patterns exhibited on the underside of the Orbiters, was projected on a white matte ceiling surface above the subjects in a manner that enabled the field of view of the subjects to be filled and enabled the simulated tile size to approximate an actual 6" by 6" "acreage" tile in terms of the visual angle subtended by the image.

Subjects participating in this task were required to view the image patterns and determine whether any of the gaps contained the presence of a "target" (i.e., whether the gaps were filled with a bright orange color or a dark brown color).

MAJOR EFFECTS

The major effects which were examined in the study were the color of the target material in the gaps between the tiles and the degree of visual difficulty. Figure 2 presents a schematic of the experimental design for these two effects.

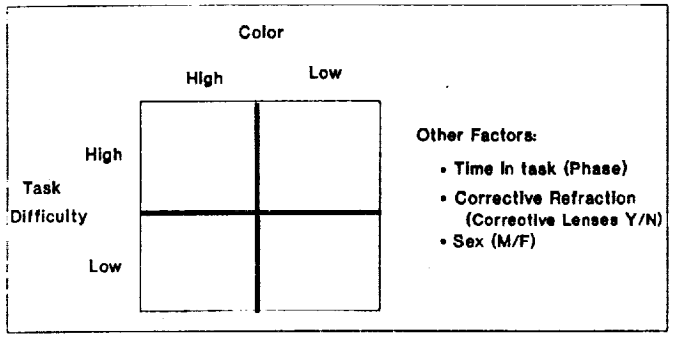

Figure 2: Schematic of Experimental Design

One of the target colors chosen was orange, a relatively high contrast color compared to the black (or grey) of the tiles, and the color of one of the widely used processing shims. The other color was a "low contrast" brown, the color of some of the darker plastic shim material.

Low difficulty targets were those that were relatively large (i.e., filled a wide gap for the length of a tile), and were located in the central area of the visual field. High

difficulty targets were smaller and were located in the peripheral areas of the visual field.

EXPERIMENTAL PROCEDURE

Forty subjects were tested. Each subject viewed 500 presentations of the "tile pattern" image. These images were presented for a viewing time of 5 seconds. Signal rate for both the orange and brown signals were 9%. Four of each color of the signals were classified as high difficulty, while the remaining five were classified as low difficulty signals.

RESULTS

The results of the statistical analysis of this experimental study are shown in Figure 3. As can be seen in the figure, both major effects of interest (i.e., color and task difficulty) were significant. In addition two significant interactions were noted.

Factor	Significance	Result
Main Effects:		
Color	«.005	Highly Significant
Task Difficulty	.025	Significant
Interactions:		
Refractive Correction X Color	.001	Highly Significant
Task Difficulty X Color	.018	Significant

Figure 3: Statistical Analysis of Experimental Study

The effect of color on target identification, the most significant effect, are shown in Figure 4. As can be seen, subjects correctly identified 93% of the orange targets . (Note: that still corresponds to a "miss rate" of 7%, a rate that could be expected to increase if the signal presentation rate of 9 per 100 were lowered). Brown, on the other hand, produced a "miss rate" OF 40%. Only 60% of the brown targets were correctly identified.

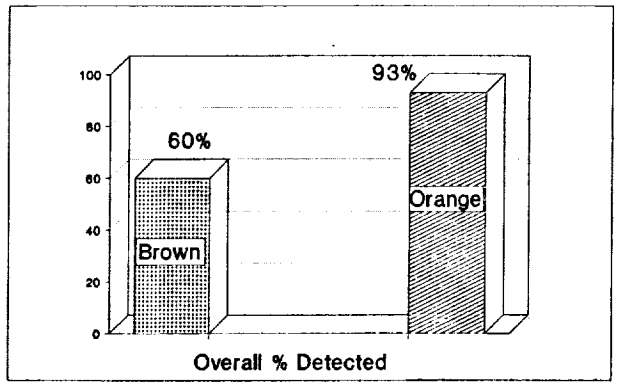

Figure 4: Effect of Color on Target Identification

CONCLUSION

This study demonstrates that a vigilance effect can be expected in Orbiter processing tasks and has delineated, for selected Orbiter processing activities, factors influencing the performance decrement. Knowledge of these effects can be readily used by process designers or in process improvement activities to help eliminate problems arising from vigilance tasks.

Results of this experiment will be used in the design of additional site studies to be conducted to further delineate the potential for vigilance problems and delineation of factors contributing to these effects in Orbiter processing activities.