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The Effects of Individual Differences and Training on Paced and Unpaced Aircraft Visual Inspection Performance

Stacey Chen, Anand Gramopadhye and Brian Melloy
Department of Industrial Engineering
Clemson University, Clemson, SC 29634-0920

ABSTRACT

The aircraft maintenance system is a complex one with many interrelated human and machine components. Inspection is the first critical step in locating and identifying non-conformities that are later removed or fixed as part of maintenance. Thus, inspection constitutes a critical step in the overall maintenance process. Significantly, 90% of all inspection, which is visual, is conducted by human inspectors. Moreover aircraft inspection is often performed under varying pacing conditions. If we are to provide the general public with a safe and reliable air transportation system, inspection must be performed effectively, efficiently and consistently over time. However, past studies in human inspection have reported large individual differences in inspection performance. Even though it is difficult to eliminate errors completely, continuing emphasis must be placed on identifying interventions to reduce errors and improve consistency in performance.

INTRODUCTION

In order for the Federal Aviation Administration (FAA) to continue to provide the public with safe, reliable air transportation, it is important to have a sound aircraft inspection and maintenance system. The inspection/maintenance system is a complex one with many interrelated human and machine components (FAA 1991, 1993) The linchpin of this system, however, is the human. Recognizing this, the FAA (under the auspices of the National Plan for Aviation Human Factors) has pursued human factors research. In the maintenance arena, this research has focused on the aircraft inspector and the aircraft maintenance technician (AMT) (e.g., Drury et al 1990; Shepherd 1992, Shepherd et al 1995).

Aircraft for commercial use have their maintenance scheduled initially by a team that includes the FAA, aircraft manufacturers and start-up operators. These schedules are then taken by the carrier and modified so that they suit individual carrier requirements and meet legal approval. Thus, within the carriers schedule there will be checks at various intervals, often designated as: flight line checks, overnight checks, A, B , C and the heaviest (D) check. The objective of these checks is to conduct both routine and nonroutine maintenance of the aircraft. The maintenance includes scheduling the repair of known problems; replacing items after a certain air time, number of cycles or calendar time; repairing defects discovered previously (e.g., reports logged by pilot and crew, line inspection, items deferred from previous maintenance) and performing scheduled repairs. Inspections often lead to repairs/maintenance, if a defect is discovered by the inspection system. In the context of an aging fleet, inspection takes a more vital role. Scheduled repairs account for only 30% of all maintenance compared to 60-80% in the earlier fleet which can be attributed to an increase in the number of age-related defects (FAA, 1991). In such an environment the importance of inspection can not be overemphasized. The problem of inspection is further compounded since the more experienced inspectors and mechanics are retiring and are being replaced by a much younger and less experienced work force. Not only do the unseasoned AMT's lack the knowledge or skills of the far more experienced inspectors/AMT's they are replacing, they are not trained to work on a wide variety of aircraft. Since humans will continue to be a part of the inspection/maintenance process for the foreseeable future, emphasis must be placed on developing interventions to make the inspection/maintenance procedures more reliable. One intervention that has been consistently effective in this environment is training. Training has been shown to improve the performance of both novice and experienced inspectors/AMTs .

Previous studies have shown that the individual differences between inspectors, training, and the pacing conditions influences performance on inspection tasks. However research has shown that training is not equally effective for all inspectors under all inspection situations. Certain inspectors perform better following training under certain inspection pacing conditions. Individual tests, which measure differences in individual abilities, have shown to be good predictors of this inspection performance. However, inspection research in the past has not linked differences in individual abilities as measured by individual difference tests to effectiveness on post training inspection performance performed under different inspection pacing conditions. We still do not know which individual characteristics are affected by training under different pacing conditions. Unless this is done we will continue to design ad hoc and generalized training programs, with the hope that they will improve performance of all inspectors under all situations. It is critical that we move beyond designing ad hoc training programs and using the "one size fits all" training strategy to improving inspection performance. In response to this need this paper addresses the broader issue of training, individual differences and pacing in inspection.

INDIVIDUAL DIFFERENCES AND INSPECTION PERFORMANCE

Several studies have been conducted that seek to classify individual attributes based on specific cognitive and physical tests with consistent data existing on individual differences in inspection performance (Drury, 1992). For example, Megaw, 1979, Drury, 1992, Gallwey, 1982, and Wiener, 1975 have concluded that an individual's personality is a known factor influencing inspector performance, while Gallwey (1982) conducted an extensive study on selection tests for predicting the performance on multiple-fault types. He concluded that selection tests for inspection should be task specific. Drury and Wang (1986) investigated the generalizability of four different tasks – the search task, the decision task, the inspection of random symbols, and the inspection of circuit packs noting that the search subtask was more task specific while decision making was more general in nature. Wiener (1975) reviewed different selection tests for visual inspection suggesting that training, motivation, and job design were better alternatives than individual differences tests for performance improvements. Table below displays several tests that have been used to measure individual differences in human inspection performance. The tests are divided into three categories: vision tests, aptitude tests, and cognitive tests. The significance in identifying individual differences in inspection performance is indicated by high, good, weak, or mixed, with N/A representing Not Applicable since these particular tests have not been used specifically for inspection tasks. Individual tests selected for this study are identified with "*."

	TEST	MEASURES	SIGNIFICANCE	REFERENCE
Vision	Visual Acuity	20/20 vision	High	Wiener, 1975; Mitten, 1957
	Lobe Size	Area around fixation point	Good	Gallwey, 1982
	Contrast Sensitivity	Luminance differences	Good	Andre, 1996
Aptitude	Harris Inspection Test	Identify unmatching objects	High –electronics	Harris, 1964
	WAIS	IQ test	Good	Gallwey, 1982
	Short Term Memory	Memory – short-term	Weak	Gallwey, 1982
	Gordon Test	Photographic memory	Good	Gallwey, 1982
Cognitive	*EFT	Identify embedded context	High	Gallwey, 1982
	Eysenck	Introversion/extroversion	Mixed	Gallwey, 1982; Wickens, 1998
	Guilford-Zimmerman	Sociability, stability restraint	Low	Wiener, 1975
	MMPI	Guardedness, anxiety	Low	Wiener, 1975
	MFFT	Impulsives/reflectives	High	Schwabish, 1984
	*Locus of Control	Introversion/extroversion	High	Eskew, 1982; Sanders, 1976
	Human Vigilance	Loss of sensitivity over time	N/A	Buckner, 1960
	*Certainty Equivalence	Risk seekers, risk aversion	N/A	Raffia, 1970
	*Myers-Briggs	Introversion, sensing, thinking	N/A	Myers, 1990

Table 1. Individual differences tests

VISION TESTS AND SIGNIFICANCE

Pacing and Inspection Performance

Pacing has known to influence inspection performance. The presentation of items in an inspection task may be paced or unpaced, meaning that an upper limit may or may not be imposed on the inspection time for an individual item. Traditionally, inspection time has been characterized as unpaced, machine-paced, or self-paced. In unpaced inspection the inspector has complete control over the speed at which the task is performed with no specific amount of time being allotted for the individual items. For a machine-paced task a machine or timing device controls the time available for inspection and the inspector cannot proceed to the next item before the maximum allotted time has lapsed while for a self-paced task the inspector can move on to the next task before the allotted time has lapsed. Studies in inspection pacing have focused either on decision making alone or on visual search and decision making combined. Drury (1973) summarizes the research on pacing in inspection by looking at inspection tasks that have both decision making and visual search components, concluding that pacing affects performance even when subjects are paced at the same rate as their own unpaced performance. Coury and Drury (1986) conducted a decision-making study in which they varied both the pacing speed and the pacing rigidity, the degree of control available to the inspector. Subjects were able to maintain their classification accuracy despite considerable variation in the time constraints for a decision-making task. However, heart rate variability, the index of mental effort, was found to be sensitive to different pacing conditions while subjective measures were not affected by pacing condition even though postural discomfort, fatigue and boredom tended to increase from the beginning to the end of each condition. Eskew et al (1982) conducted a study of pacing and Rotter's Locus of Control Test that measures introversion and extroversion, finding significant differences between personality and pacing variables. Self-paced internals made fewer false alarms than self-paced externals while machine-paced internals made more false alarms than machine-paced externals. Finally, Freeman and Miller's (1989) study observed that unpaced subjects performed significantly better on correct decisions and number of misses than machine-paced. In the aircraft inspection environment pacing is an important factor that can potentially influence inspection performance. When an aircraft arrives for inspection, initially, the aircraft is cleaned and access hatches opened so that inspectors can view the different areas. This activity is followed by a heavy inspection check. Since such a large part of the maintenance workload is dependent on the discovery of defects during inspection, it is imperative that the incoming inspection is completed as soon as possible after the aircraft arrives at the inspection maintenance site. Furthermore, there is pressure on the inspector to discover critical defects that necessitate long follow-up maintenance times, early on in the inspection process. Thus, there is a heavy inspection workload at the commencement of each check. It is only after the discovery of defects that the planning group can estimate expected maintenance workload, order replacement parts and schedule maintenance items.

CONCLUSIONS

In summary, studies are needed that will (a) compare and evaluate the effects of training versus no training on inspection performance for inspection tasks performed under different paced conditions and (b) relate changes in post training inspection performance to differences in individual abilities. It is anticipated that the findings obtained from such research will throw new light on the effectiveness of feedback training on inspection performance performed under different pacing conditions. Moreover, the individual difference tests should help us identify the true effects of training under different pacing conditions. Furthermore, such studies need to be conducted under different inspection settings which will enable us to extend the findings to a wide variety of visual search tasks that exist today.

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