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THE EFFECTS OF CLOSED LOOP TRACKING ON A SUBJECTIVE TILT THRESHOLD IN THE ROLL AXIS

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SUMMARY

The indifference thresholds for the perception of tilt in the roll axis were experimentally determined in a moving base simulator under three tracking task difficulties. The threshold level determined in this experiment is approximately 5 to 7 degrees (.1g).

INTRODUCTION

In ground based simulators, unlike aircraft, false tilt cues may occur when they are rolled. The amount of tilt which can be detected by the pilot in the simulator, defined as the indifference threshold, appears to be a function of the task being performed. To eliminate the false tilt cues that occur when the indifference threshold is exceeded, washout schemes are used to limit the motions of the simulator. This is often accomplished by limiting the amount of roll of the simulator while still allowing the acceleration and other helpful cues to be felt by the pilot. In the past the washouts used were based on what felt good to the pilot in the simulator. Very little data is available relative to what this threshold is, see reference 1, and what factors, if any, alter the level of indifference. Data in the past has dealt with determining the absolute threshold. One set of data, see reference 2, does show that the "absolute" threshold increases when workload is increased. This prompted an investigation to determine the effect of workload on the indifference threshold level for use in washouts and in motion related parameters of pilot modeling.

An experiment was performed to determine the indifference threshold and the interactive effect of the tracking task on the threshold value. This experiment and associated results are presented in this paper.

METHOD

The basic idea behind the experiment was to have a subject track a closed loop disturbance nulling task and then superimpose a random appearing ramp (tilt input) to the motion loop of the simulator. Figure 1 is a block diagram

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of the motion and visual systems used in the experiment showing the location of the disturbance input and the tilt input to the motion plant in the system. The only input was the disturbance input so the display was the negative of the simulated plant position. When the subject could detect the tilt input, he was to indicate the direction of the tilt via a hand-held indicator containing a left and a right thumb actuated pushbutton. The subject was instructed to hold the pushbutton down until he no longer felt that he was tilted. The time histories of the chair position, the tilt input and the hand-held indicator signals were recorded and later analyzed.

The experiment was run on the Roll Axis Tracking Simulator (RATS) at the Aerospace Medical Research Laboratory at Wright-Patterson Air Force Base. The RATS is capable of simulating the roll dynamics of a high performance aircraft, in this case, an F-16. The plant dynamics are described by equation 1 with limits of 180°/sec and $400°/sec^2$. The cab contains a CRT mounted at the axis of rotation which is through the head of the subject. The subject viewed the display shown in figure 2 which was 26 inches away. The subject used a force stick mounted on the right side of the cab to control the tracking task. To prevent the subject from experiencing any external cues, a shroud inclosed the cab, white noise was injected in the helmet and the room lights were extinguished. In addition, a harness was used to keep the subject in his seat while the cab was in motion.

Three sum of sine inputs, simulating white noise passed through a low-pass filter with a double pole at 2 radians, were used with RMS values of .933, 1.40, and .467 pounds which resulted in 14, 21, and 7 degrees/second root mean squared (RMS) variance in the visual error. A group of ten subjects were exposed to the inputs in the order mentioned above. They ran 4 runs a day for 3 days, with each run lasting 165 seconds. The subjects had been trained from a previous experiment, therefore, minimum training was required. Data from the last two days was used for subsequent analysis. An example of a data run can be seen in figure 3. The top trace is a time history of the negative visual error (simulated plant position) seen by the subject. The negative of the visual error is shown so that it can easily be compared to the actual motion plant seen in trace 3. This was the tracking task he was trying to null out by keeping the wings on the display level with the dashed reference line. The second trace shows the offset signal that was added to the cab position. The resulting cab position during the tracking task is shown in trace 3. A run consisted of from zero to four of the offset signals to maximize randomness between runs. The offset signal itself occurred at a rate of 1°/sec with limits of ±20 degrees. The 1°/sec value was chosen because it is below the roll velocity threshold of 2°/sec, see reference 1. The last graph is the output of the hand-held indicator the subject used to indicate when the tilt was felt.

In addition to the tracking data taken, a set of baseline data for each subject was recorded. This data provides a baseline indifference threshold, comparable to the absolute threshold data taken in previous experiments. The subject was asked to sit quietly in the cab while the cab was tilted, using the same tilt input described earlier. The subject was to indicate the direction of tilt as he did before. The tracking task was not present and the display remained fixed on the screen.

RESULTS

The results are shown in figures 4 through 7 and summarized in figure 8. For each group, the offset angle, at the point when the indicator button was pressed was recorded and placed in groups of half degree increments. The number of points recorded in each half degree group was then plotted in histogram form with the mean and standard deviation shown for each group. The mean values for the indifference threshold increases with the difficulty of the task. Fewer data points were needed for the baseline data due to the smaller amount of variance across subjects.

The summary shows a baseline level of 3.48° (.06g) which jumps to 6.46° (.113g) with the least difficult task and 7.56° (.132g) with the most difficult. These results are discussed in the following section.

DISCUSSION

From the baseline data, the indifference threshold level is 3.48° (.06g). This value can be compared to data taken from other experiments where the absolute threshold was determined but, the results from this experiment are 3 to 30 times higher, see reference 1. This is due to the conditions under which the experiment was run. These conditions added extra loading to the subjects tilt detection, similar to the kind of loading he would receive when running in a simulator. Under these "real world" conditions, the simulator environment, a useful measurement of the indifference threshold is made and can be directly applied to washout designs and used in pilot modeling.

Figures 5 through 7 show the results when tracking tasks of varying difficulties are added to the baseline conditions. The results of all four conditions, summarized in figure 8, contained the type of trend as expected, see reference 2. The summary shows a sharp jump from the baseline to the least difficult of the three tracking tasks and then increasing threshold levels with the difficulty of the task. The various difficulties were obtained by increasing the tasks RMS value which had the effect of changing the signal to noise ratio of the system. This change accounts for part of the increase in the threshold levels as well as the increase in the variance of the data. The relatively large jump from the baseline is due to the initial loading of the subject by the tracking task.

CONCLUSIONS

In this paper, an experiment to investigate the effects of the tracking task workload on the indifference threshold is described. Based on the results and the discussion, the following conclusions can be drawn.

1) The indifference threshold increases with task loading.

2) The tilt indifference threshold while performing a tracking task is approximately .1g.

REFERENCES

1. Zacharias, G.: Motion Cue Models for Pilot-Vehicle Analysis. Technical Memorandum, Bolt Beranek and Newman Inc., Cambridge, Mass., under Contract No. F33615-77-C-0506, September 1977.

2. Hosman, R.J.A.W., van der Vaant, J.C.: Thresholds of Motion Perception Measured in a Flight Simulator. Proc. of the Twelfth Annual Conference on Manual Control, Ames Research Center, Moffett Field, California, May 1976.

3. Peters, R.A.: Dynamics of the Vestibular System and Their Relation to Motion Perception, Spatial Disorientation and Illusions, NASA CR-1303, 1969.

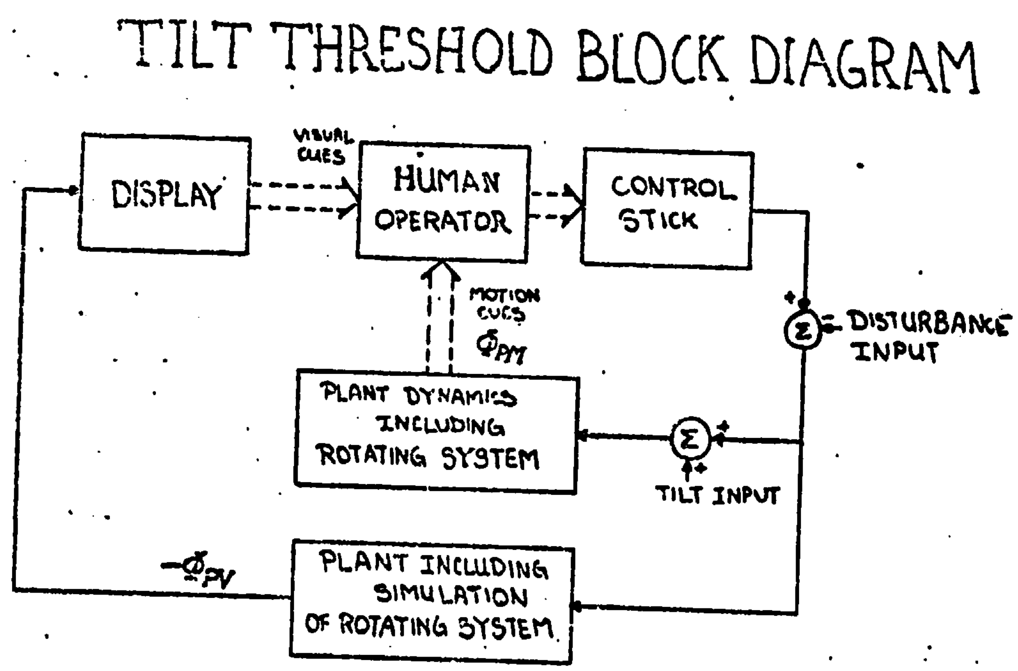

Fig. 1. Experimental Block Diagram

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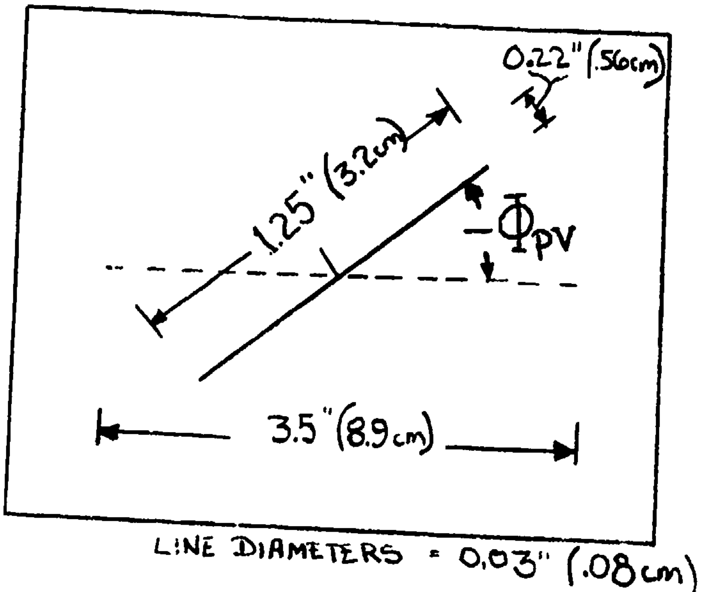

Fig. 2. Visual Display

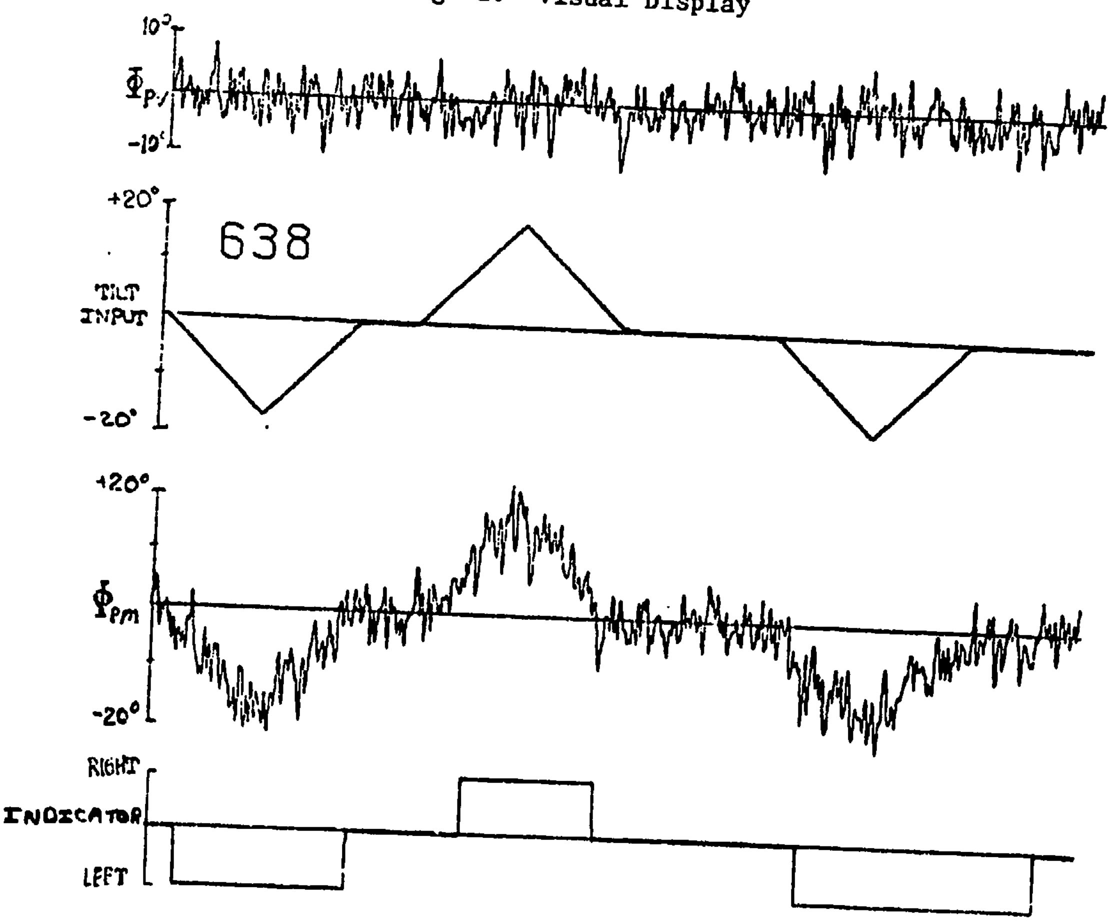

Fig. 3. Sample Data

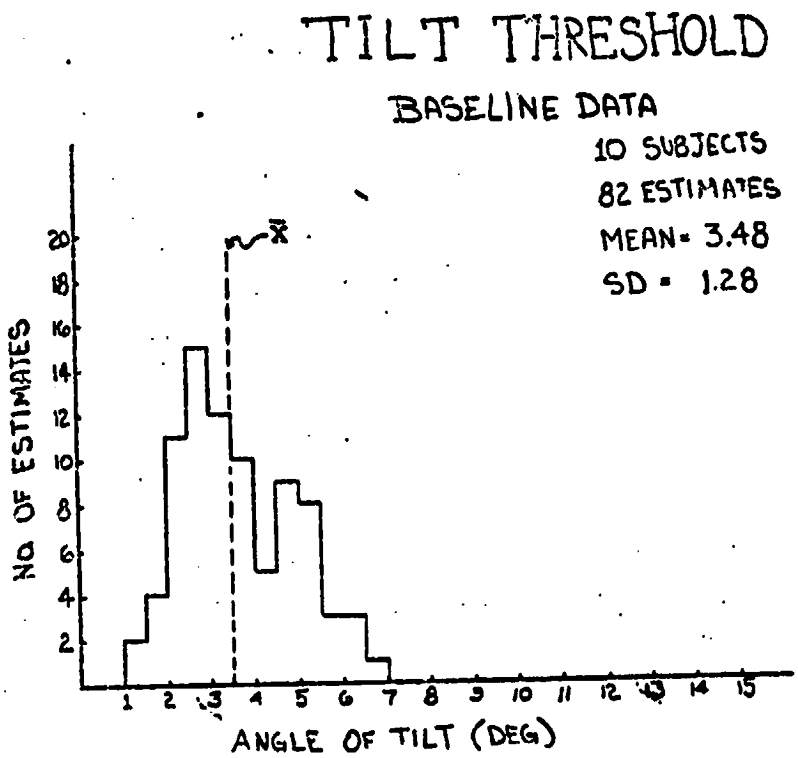

Fig. 4. Results of the Baseline Data

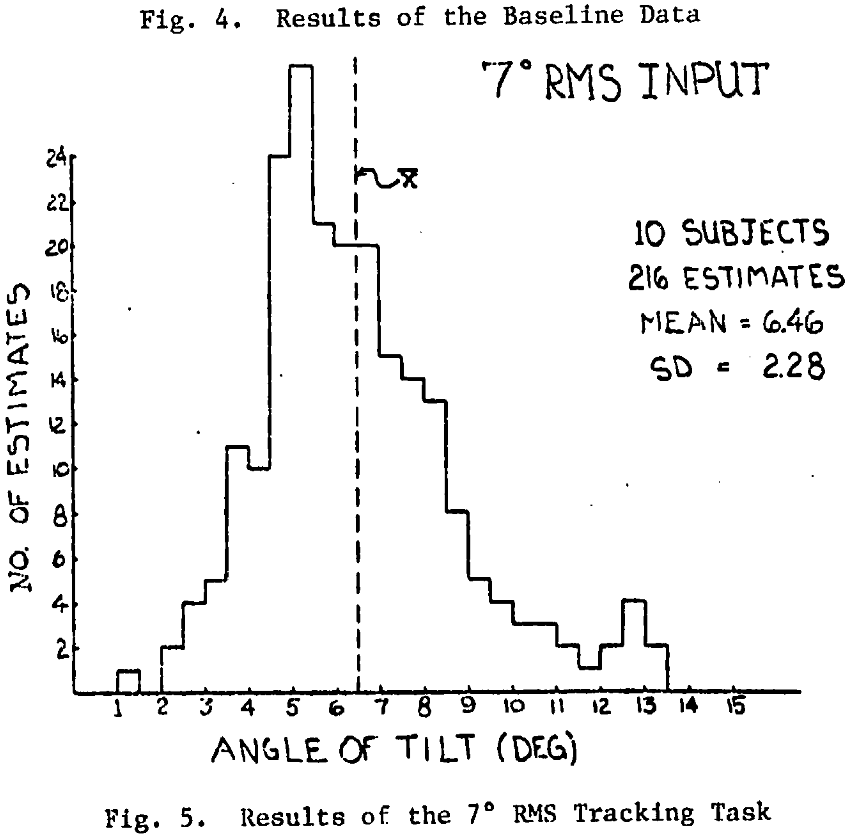

Fig. 5. Results of the 7° RMS Tracking Task

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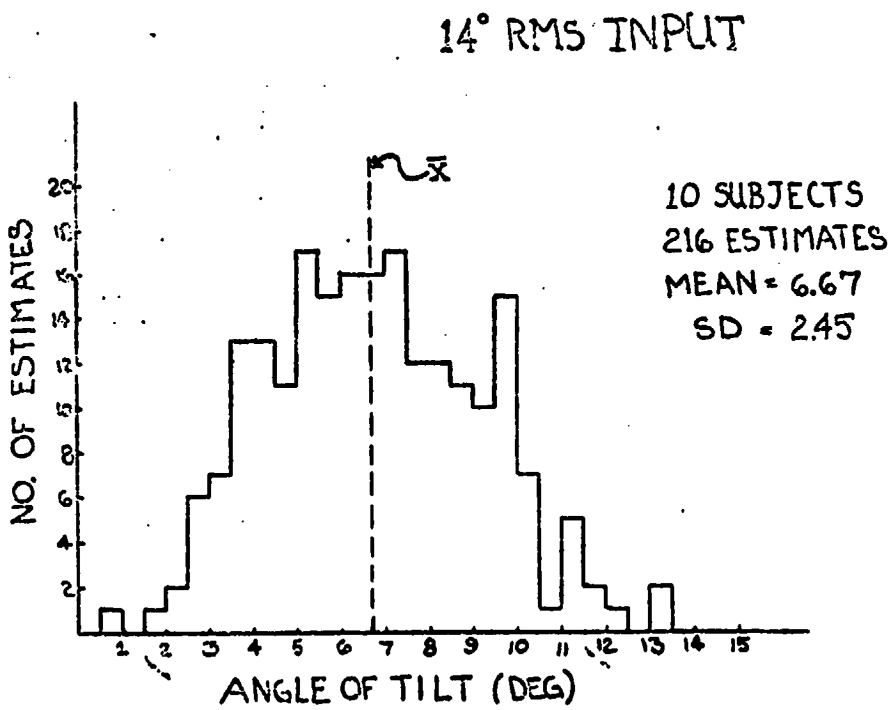

Fig. 6. Results of the 14° RMS Tracking Task

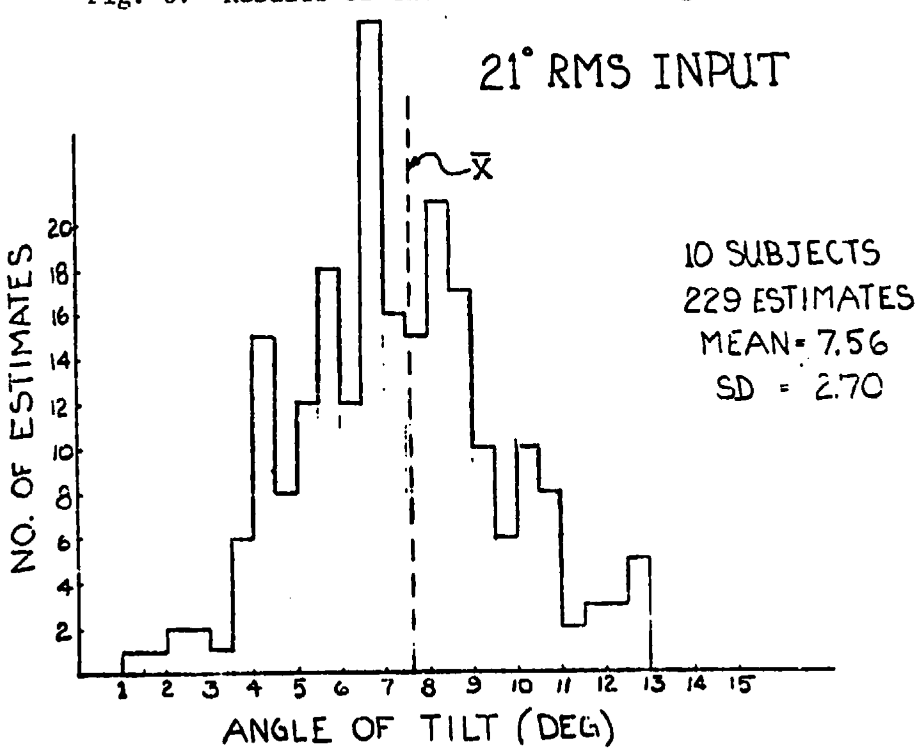

Fig. 7. Results of the 21° RMS Tracking Task

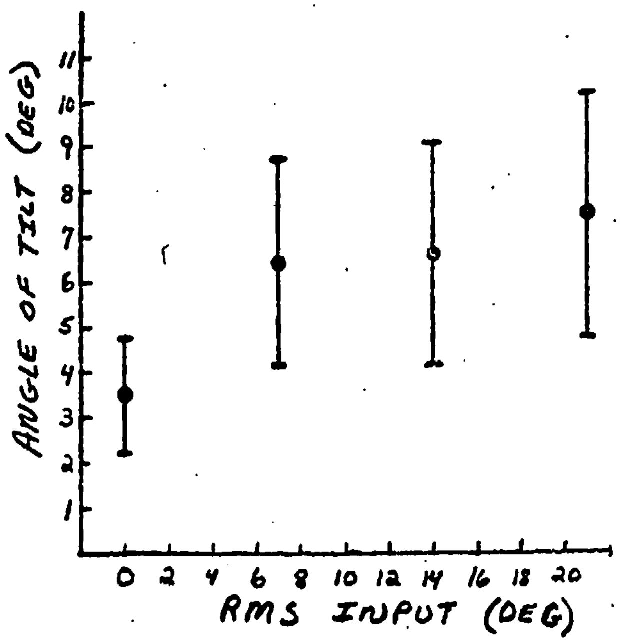

Fig. 8. Data Summary