Effects of Pressure Suit Inflation on Reaction Times of Project Mercury Astronauts

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THE SUBJECT MATTER of this paper is properly concerned with a sub-area of bio-astronautics, which may be called biomechanics. Specifically, we were interested in obtaining estimates of performance from the Project Mercury austronauts while they were wearing the Mercury full pressure suit and working on an intermediate mock-up of the Mercury capsule panel. It was considered mandatory to assure proper fit of the individual astronaut's suit and to begin familiarizing him with the use of the suit. Accordingly, the following experiment was designed in the interest of accuracy and to avoid wasting potentially valuable information.

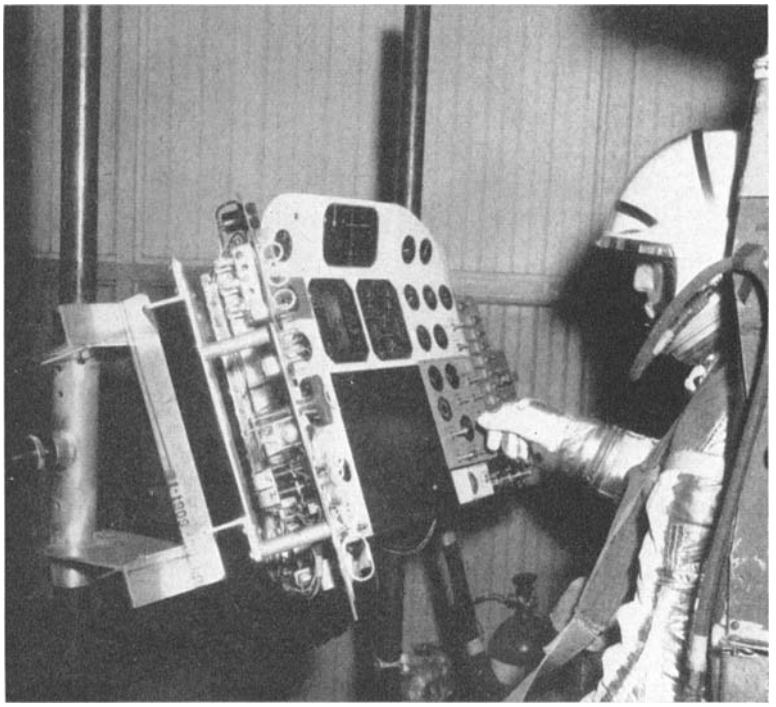

Fig. 1. Mercury panel installation at the Air Crew Equipment Laboratory.

MATERIALS AND METHODS

Subjects:—The subjects participating in this study were all well qualified test pilots and astronaut nominees in the Project Mercury program. Six of the seven astronauts served as subjects in most of the procedures described below.

Apparatus:—Figure 1 shows the mock-up of the Mercury panel installed at ACEL. A

From the Air Crew Equipment Laboratory, Naval Air Material Center, Philadelphia, Pennsylvania.

realistic stimulus array was fabricated from McDonnel Aircraft Corporation specifications with all the controls, switches, and lights on the panel in operating condition. The attitude con-

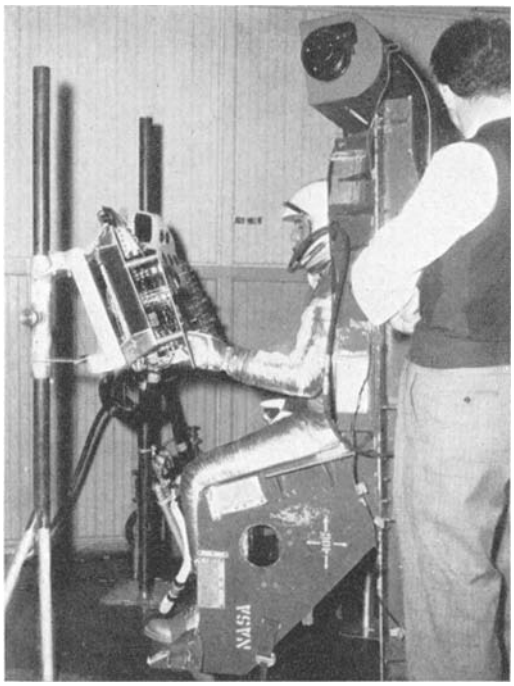

Fig. 2. Mercury panel with operator at 0 psi.

trol was not included because of the particular complexity that function entails. Instead, two conventional flight control sticks were modified and integrated into the task. One control stick was mounted near the arm rest on each side of the couch support on a sliding bracket.

A reaction time device was constructed such that signals, in the form of ongoing indicator lights, could be presented to the subject. Any number of stimuli from one to twelve could be presented simultaneously, requiring him to respond by actuating the appropriate switches or controls. The timing device allowed two aspects of the subject's response to be measured: latency, or that period between the presentation of a signal and the beginning of subject's hand movement, and reaction time, which was the period between initiation and completion of the response or response sequence. In order to facilitate this distinction and the general testing procedure, the subject was required to return his hands to the control sticks and to depress the armaments control switch. This "home" position enabled the subject to receive the next stimulus presentation. The number of responses, the number of errors, the latency of response, and reaction time were recorded by the experimenter.

Procedure:—Each of six subjects was first tested with the suit at 0 psi, or more accurately, ventilation air pressure (Fig. 2). Approximately thirty-five minutes was required to finish this

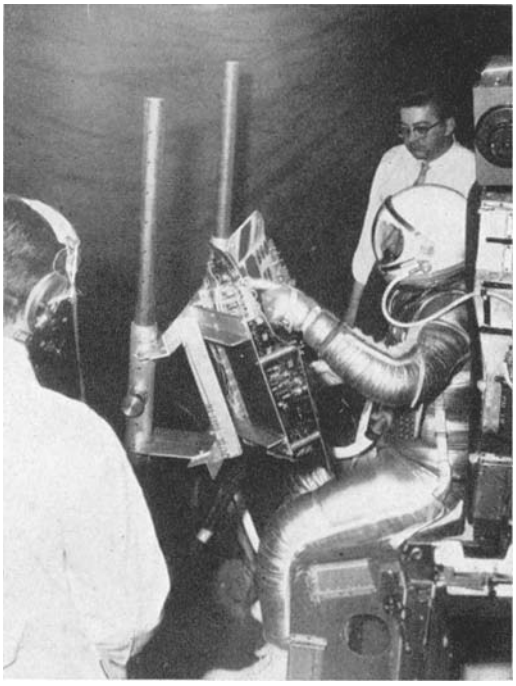

Fig. 3. Mercury panel with operator at 5 psi.

portion of the test. During that time each subject received twenty-five sequence stimuli involving groups of six switches or controls, and about fifty single stimuli involving only a simple response to one light. Ten minutes were allowed to elapse before the subject's suit was inflated for the 5 psi test. When the suit had been inflated to the desired pressure, as shown in Figure 3, and the flow of vent air adjusted, the

second series of stimuli were presented. These were given in the same order as they were in the earlier 0 psi run. Two experimenters were always on hand, apart from the personnel needed to handle inflation of the pressure suit. One experimenter recorded the latencies, reaction times, and errors, while the second programmed the stimuli and monitored the intercom.

TABLE I. MEAN REACTION TIME (RT) SCORES FOR FOUR ASTRONAUTS

Reaction Time for Single Response (Seconds)			Reaction Time for Response Sqeuence (Seconds)		
Stimulus	0 Psi	5 Psi	Stimulus	0 Psi	5 Psi
1	1.3	3.5	A	7.8	14.9
2	1.2	2.0	B	5.3	10.0
3	1.3	2.8	C	4.5	7.8
4	0.9	1.5	D	6.9	12.6
5	0.9	2.0	E	4.1	6.8
6	0.8	1.7	F	4.8	5.2
7	1.1	2.6	G	4.4	8.9
8	1.0	1.9	H	4.3	8.6
9	0.8	1.8	I	4.3	10.0
	$\overline{X}_0$=1.03	$\overline{X}_5$=2.20		$\overline{X}_0$=5.16	$\overline{X}_5$=9.42

RESULTS

The quantitative data presented use only the reaction time scores obtained from four astronauts. Changes in the prescribed routine created by other demands made some of the data incomparable. It must be emphasized that this work was done as a part of familiarization, and that these data were collected on either the first or the second occasion the subjects had worn this particular model of the pressure suit.

Table I shows the reaction times for both the single responses and the response sequences under the 0 psi and 5 psi conditions. (The latency measures were not subject to statistical analysis since it was obvious by inspection that this aspect of the response was not affected by suit pressurization.) The various stimulus arrays are numbered along the left. It is apparent and expected that reaction times for the 5 psi condition are greater than those for the 0 psi condition.[1] The difference between the means was significant ($p < .01$) using the Wilcoxn Signed-Rank test. Certain controls, in fact, could not be properly actuated, and at times even reached, by the astronaut wearing the inflated suit. This experimental fact must be assessed in the light of operational need to determine whether the finding has any operational significance.

Another consideration is the possibility of inadvertent actuations occurring under the 5 psi condition. A cumulative recorder indicated the slope (i.e., rate of response), correct responses, and errors (or inadvertent actuations). While the astronauts typically did not make errors under the 0 psi condition, four to six inadvertent actuations were frequently made under the 5 psi condition. It is interesting, also, to note that these errors were truly inadvertent; the astronaut was notified of a wrong response by the monitoring illumination of the "abort" light on the panel—this never failed to surprise the subject, since he was unaware that he had committed an error. Frequently, the inadvertent actuation involved contact with adjacent toggle switches, some of which were supposedly protected with lucite guards.

Let it be noted that operationally the Mercury console is typically a one response device; the multiple response data were included for experimental completeness.

DISCUSSION

Basically, both the pressure suit configuration and the Mercury panel reflect sound research

and development design. Thus, this brief report does not necessarily mean that changes in either area are prescribed. Some of our other research, for example, has shown that properly motivated subjects can learn, with repeated testings, the alternative postural adjustments and motor movements required for effective pressure suit mobility.[1] In almost every instance, speed and accuracy of movement in the 5 psi condition have been reduced to the normal operating range.

The differences in reaction time reported in the present study represent statistically significant differences. The operational significance of these differences remains to be assessed by comparison with the mission profile. Assuming, however, that rapid and accurate movements will be part of any particular performance in the capsule makes us believe that the findings reported herein deserve operational consideration.

First, the possibility of repeated training reducing the 5 psi reaction time and number of errors should be investigated further. (It is again noted that this was essentially a first experience for these subjects). At the moment, it would appear that six hours of 5 psi training on the final capsule panel would be helpful. Secondly, the use of locking toggle-switches instead of lucite guards should be considered in order to minimize the probability of inadvertent actuation. Thirdly, the assignment of control locations in *all* space craft should be made on the basis of a realistic compromise among such factors as mechanical limitations, anthropometry ranges and actuation need with an inflated pressure suit. The suit has been constructed such that if a well-planned cockpit and panel layout is designed, its controls should easily be reached by the pressure-suited operator.

Another consideration concerns the true measurement of performance efficiency of pressure-suited operators. The amount of work expended or physiologic output must be measured simultaneously with motor performance. It was observed, for example, using some of the astronaut population, that heart rate increased from 66 beats per minute under the 0 psi condition to 80 beats per minute under the 5 psi condition while the operator worked on identical task profiles. Thus, the amount of effort expended by an astronaut in an inflated pressure suit in order to attain performance values similar to those obtained in the uninflated condition may be considerable—particularly so when long periods of time are involved and other stressors (e.g., excessive heat, acceleration) are involved.

SUMMARY

The reaction times of the Project Mercury astronauts were tested under two conditions of pressure suit inflation: 0 psi and 5 psi. Under the 5 psi condition, reaction times increased significantly as did the frequency of inadvertent actuation.

REFERENCE

1. Burns, N. M. and Gifford, E. C.: Pressure Suit Mobility: A preliminary study. Naval Air Material Center, Philadelphia, Pa. (Report NAMC-ACEL-412).

Longevity in the U.S.S.R.

In Britain 0.3 per 100,000 of the population may confidently expect to top their century. In the Soviet Union, however, the chances of becoming a centenarian are at least thirty times as great according to a recent report, whilst in some parts of the Union, such as Azerbaijan, with its 84 centenarians per 100,000, the chances improve more than 250 per cent. The census upon which this is based shows that there are 21,708 centenarians in the U.S.S.R., 592 of whom are "at least over 120."—From *The Practitioner*, 1961.