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Reliability of a "Shuttle" Reaction Timer

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ABSTRACT

Reaction, movement, and task times refer to the times needed to initially respond to a stimulus, make the specified movement, and complete the entire task. These three times can characterize the function of a neuromuscular circuit. This study evaluated the reliability of a simple reaction timer designed to mimic a Shuttle task (turning on an overhead switch). A "Shuttle" reaction timer was designed in which a joystick rested between the subject's legs and a Shuttle switch was mounted overhead. The stimulus was presented both visually and audibly. A monitor that was placed in the subject's visual field displayed scenes of spacecraft and airplanes. Reaction and movement times were recorded by a computer. Task time was the sum of the reaction and movement times. Ten subjects were given an orientation session to the instrument and then completed 2 blocks of 25 trials on each of the next 3 days. For each block of trails on the 3 days, the 25 trials for each subject were averaged to provide a single measure of reaction time. Intraclass correlation and a 2x3 repeated measures ANOVA were used to evaluate the reliability and to test for differences in mean reaction time. Mean (SD) reaction times in msec are shown below:

	Day 1	Day 2	Day 3
Block 1	291 (35)	276 (30)	263 (24)
Block 2	286 (40)	270 (36)	265 (18)

Neither the means across days nor the means between blocks were significantly different. The intraclass correlation was 0.908. The Shuttle reaction timer is a reliable means of measuring reaction time. The timer may be used to evaluate the effects of muscle deconditioning on reaction, movement, and task times.

INTRODUCTION

Changes in reaction and movement times as a result of long-term space flight could pose a potentially hazardous situation during entry and landing. To date, very little research has been conducted examining the effect of space flight on reaction and movement time. Reaction and movement times refer to the time required to initially respond to a stimulus and to make the specified movement. Task time refers to the summation of these two times.

Clement, et al. (2) observed no changes in the reaction time of an arm flexion motion following a seven-day space flight (n = 2). Reaction time was measured as the time elapsed between initiation of the auditory stimulus and the earliest detectable change in the arm accelerometric signal. Movement and task times were not reported. The need for further studies is warranted because of the apparent limitations in sample size. An alternative to actual space flight would be to study the effects of simulated microgravity on reaction, movement, and task times.

Simplistic motions, such as elbow flexion, are often used as a model for evaluation of reaction and movement time. It has been shown that simple reaction time (SRT) increases as the response becomes more complex (1). Most operational tasks on the Shuttle are made up of complex movements. The evaluation of reaction, movement, and task times for an operational task is, therefore, needed. A reaction timer was constructed to simulate such a task. The scenario of a pilot turning on an overhead switch was chosen as a task vital to the safe entry and landing of the spacecraft. The purpose of this study was to determine the reliability of a newly designed reaction timer which could fractionate complex task times into reaction time (time elapsed between visual/auditory stimuli and initiation of movement) and movement time (time elapsed between initiation of movement and turning on the overhead switch).

METHODS

Construction. A reaction time measurement system (RTMS) was constructed to study the effects of simulated microgravity on human reaction time. This system was designed and built to operationally mimic the Shuttle pilot position and to establish and implement certain test protocols utilizing the various Shuttle display and control apparatus. The particular display and control devices utilized in the tests were the flight control joystick, the main panel alarm indicator, and the overhead control panel (Figure 1).

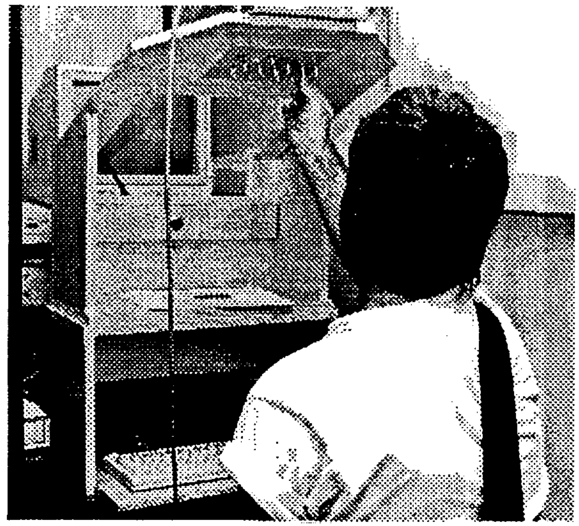

Figure 1 - Reaction Timer

The flight joystick was utilized to provide an accurate starting position of the subject's hand. The visible main panel alarm indicator, in conjunction with an audible alarm, was used as the subject stimulus, and the overhead control panel provided the target switch for the subject to actuate after being stimulated. A monitor was placed above the main panel and below the overhead panel so that scenes of space and air flight could be displayed.

A single chip microcontroller unit (MCU) and associated electronic interface circuitry was constructed to measure reaction time during this complex movement. The interface circuitry was designed to allow the MCU to control the activation of the audible and visual stimuli, to monitor the position of the test subjects' switches and operating control selectors, and to permit interconnection of the MCU and a host computer system. The subjects' switches were located in the flight joystick and on the overhead panel. Computer software for satisfaction of the test protocol was written and transferred permanently to the MCU. The time base was derived from a high stability, four megahertz, crystal oscillator contained within the MCU that enabled event timing accuracy to within ± 1 millisecond. The

MCU measured reaction, movement, and task times. These times were recorded and saved to a host computer.

Protocol. Ten subjects were given an orientation session to familiarize themselves with the instruments and procedures. Subjects were seated at arm's length from the overhead control panel. The height of the joystick, control panel, and chair remained constant for all individuals. Subjects sat in the chair with a restraining strap placed across the right shoulder. Reaction time was assessed using the right arm of all subjects. Initiation of a trial began when the subject depressed the joystick trigger. The visual/auditory stimulus occurred randomly between one and four seconds after depressing the trigger. Subjects responded to the stimulus by activating the specified switch on the overhead control panel. A monitor displaying space and aviation scenes was placed in the subject's visual field to provide competing information that would normally be present during entry and landing of the Shuttle.

All ten subjects completed two blocks of 25 trials over the next three days, with the two blocks being separated by a two minute rest period. Reaction and movement times were recorded and saved to a host computer. For each block of trials during the three days, the 25 trials for each subject were averaged to provide a single measure of reaction time. Statistical analysis included an intraclass correlation and a 2x3 (blocks of trials versus days of testing) repeated measures analysis of variance to determine mean differences in reaction time.

DISCUSSION

The accuracy of the reaction timer hardware can be attributed to the single chip microcontroller unit that controls the activation of the stimuli, monitors position of the switches, and transfers results obtained to a host computer system. Elapsed time is accurate to within ± 1 millisecond due to the four megahertz, crystal oscillator contained in the microcontroller unit.

Reaction and movement times can provide valuable information pertaining to a skilled motor performance. Reaction time can be affected by a variety of factors including fatigue (4), repetition of stimuli (3), task complexity (1), and sensory modality employed (5). The effects of microgravity on reaction and movement times require evaluation. Decrements in skilled motor performance during extended space flight may pose serious problems to the successful completion of a mission. The reaction timer described in the present study was constructed to initiate studies evaluating the effects of microgravity on components of skilled motor performance. Before such studies could proceed, however, it was necessary to assess the reliability of the reaction timer.

The present study demonstrated that reaction time of a complex movement can be performed consistently over several days. It is well accepted that the greater the complexity of the task, the greater the reaction time (1). The present study demonstrated a significant correlation over blocks and days despite the increased complexity of the task. This indicates that the reaction timer described can be used to reliably assess possible changes in reaction time incurred by simulated or actual microgravity.

RESULTS

Analysis of variance indicated no significant differences between means over the three days of testing (Figure 2).

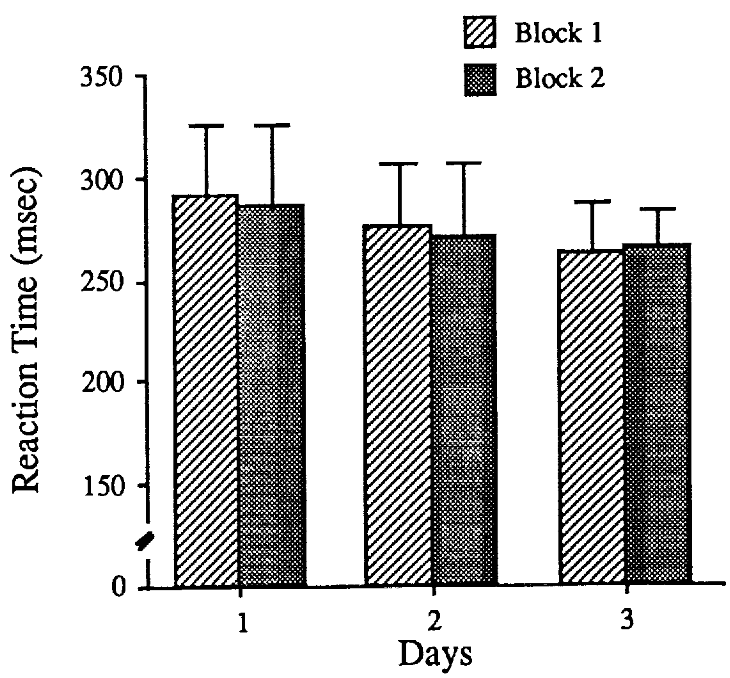

Figure 2 - Reaction Time

Intraclass correlation provided a value of 0.908. These results indicate that the reaction timer can be used as a reliable and consistent means of assessing reaction time.

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