AD-A124 777 BEHAVIORAL-PERFORMANCE EFFECTS FROM A HIGH-NEUTRON LOW-GAMMA RADIATION PULSE EXPOSURE(U) SCHOOL OF AEROSPACE MEDICINE BROOKS AFB TX G C BROWN ET AL. 1/1

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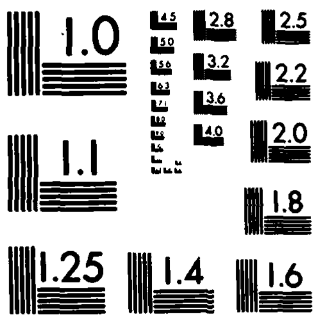

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BEHAVIORAL-PERFORMANCE EFFECTS FROM A HIGH-NEUTRON, LOW-GAMMA RADIATION PULSE EXPOSURE

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December 1982

Final Report for Period June 1981 - December 1981

Approved for public release; distribution unlimited.

USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235

NOTICES

This final report was submitted by personnel of the Weapons Effects Branch, Radiation Sciences Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order 7757-05-50.

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The animals involved in this study were procured, maintained, and used in accordance with the Animal Welfare Act of 1970 and the "Guide for the Care and Use of Laboratory Animals" prepared by the Institute of Laboratory Animal Resources - National Research Council.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

The technical report has been reviewed and is approved for publication.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A self-paced, 3-light, 3-lever discrete avoidance behavioral task was initiated to study the behavioral performance effects of a high-neutron, low-gamma radiation pulse exposure (550-650 rads, 5.5:1 n/g ratio). Eight rhesus monkey subjects performed the task for 4 hours (3 1/2 hours postexposure). The subjects were monitored daily for 3 days postexposure. For the exposure day only, five subjects had a decrease in correct responses, seven had increased reaction times, and six experienced productive emesis within 3 1/2 hours, although the

20. ABSTRACT (Continued)

performance degradations were not severe. An extrapolation to human performance indicates that time-critical tasks (e.g., aircraft landing on a carrier) could be significantly impaired.

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BEHAVIORAL-PERFORMANCE EFFECTS FROM A HIGH-NEUTRON, LOW-GAMMA RADIATION PULSE EXPOSURE

INTRODUCTION

Nuclear weapons produce blast, thermal x-ray, and electromagnetic pulse as well as nuclear radiations of alpha, beta, gamma, and neutron. The acute radiation (gamma) exposures over a wide range of doses have been described by Gerstner (5), Zellmer (15), and Albanese and Pickering (1). With whole-body sublethal doses--i.e., 300 rads gamma (tissue)--human subjects exhibit mild to moderate prodromal reactions. With doses in the range of 300-800 rads, reactions are characterized by fatigue, nausea, vomiting, diarrhea, dizziness, and anorexia. Exposure levels beyond 800 rads may include extensive vomiting and prostration. (See Figure 1.) These effects may gradually abate but may reappear after 2-3 days. Depending on the time of onset and duration, some of these symptoms may moderately or severely impair the ability of aircrews to perform specific tasks.

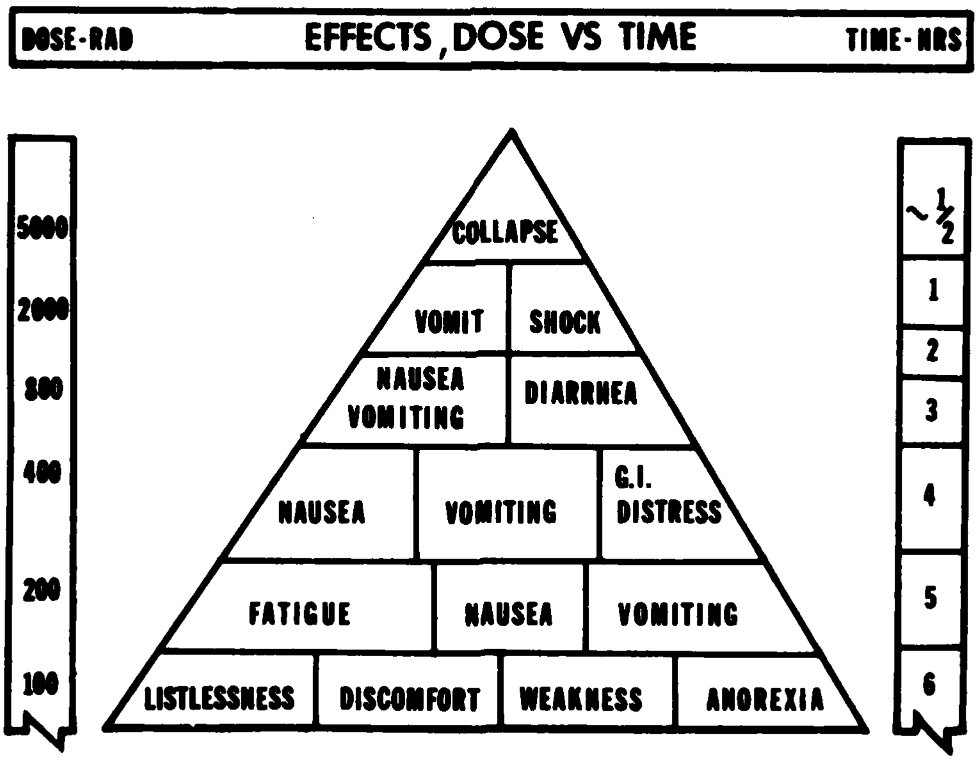

Figure 1. The prodromal syndrome (From John E. Pickering, USAF School of Aerospace Medicine, 1976.)

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Data are needed about man's ability to operate after exposure to high-neutron--low-gamma environments. The only large body of data for neutrons and nontherapeutic human exposure is the followup on the Hiroshima and Nagasaki survivors. The relative value of the Japanese neutron data has diminished with recent evaluations and revisions. The end point has been death rates from various types of cancers. Leukemia mortality rates appeared to be higher in Hiroshima than in Nagasaki. Based on tentative 1965 dose estimates, the differences were attributed to a much higher neutron component at Hiroshima (3). Recently, William Lowe and Edgar Mendelson (9) at Livermore sharply revised the bomb dosimetry estimates. Their proposed leukemia mortality dose-response curves show no difference between the two cities. They feel the neutron element was so low in both cities that only very limited conclusions may be drawn about the relative biological effectiveness of neutron and gamma radiation. The debate, however, is by no means settled.

Because man is a crucial part of Air Force systems, the identification of "sure safe" and "mission failure" radiation doses, with effects of time considered, is essential. The capability of Air Force systems to withstand exposure to a nuclear environment without losing their mission-completion capability is termed "systems nuclear survivability." Within limits, the aircraft frame and additional safety devices can provide protection from many nuclear-weapon effects but not from nuclear radiation. An enhanced-weapon's dispersion distances are considered to be significantly larger than those of current weapons, yield for yield. If a weapon is released from a low altitude, the crewmembers who drop the device may receive partial exposure from it. It is therefore necessary to understand the operational significance of behavioral-performance degradation; i.e., 1) the onset and duration of early transient incapacitation and performance decrement, and 2) immediate permanent incapacitation, although this would not be expected to occur at doses considered in this report.

Flying requires highly complex tasks that must be performed for extended periods of time. Normal aircraft operation involves many stressors including task complexity, workload, fatigue, and physical and psychological stressors. How even small amounts of radiation stress would affect mission completion must be assessed. Even with a protracted exposure, a total dose of 300 rads (gamma) has been shown to impair performance and increase reaction times (2,13). Even less is known about the behavioral effect of neutron doses; the equivalent number of rads apparently do not demonstrate the same exposure effects. Examples in the literature that compare gamma and neutron exposure effects are studies by George et al. (4) and Thorp and Young (12).

The study by George et al. investigated the relative effectiveness of fission neutrons for performance decrement in the miniature pig. The incident neutron/gamma (n/g) ratio was 10:1; the dose rate was 2000 rads/minute. Mid-brain doses ranged from 1500 to 36,000 rads. The task for the pigs was to traverse on cue a two-chambered shuttlebox. George reported a distinct difference in the response of the pigs to supralethal doses from the neutron field than to similar doses from the gamma field. He found that early performance decrement, early transient incapacitation, and immediate permanent incapacitation all occurred at much lower doses from the gamma exposure than from the neutron. With early performance decrement and death within 48 hours as end points and with the gamma exposure as the reference point, the relative effectiveness of the neutron field was 0.23.

Thorp and Young (12) evaluated the relative effectiveness of neutrons for demonstrating the symptoms of early transient incapacitation in 58 monkeys (*Macaca mulatta*). The neutron/gamma ratio was 10:1. The dose rate was 2000 rads/minute, and the midbrain doses ranged from 2200 to 4400 rads. The task for the monkeys was a visual-discrimination two-choice problem, between a square and a circle. The subject had to press a lighted symbol displaying the square. Significantly higher neutron doses than gamma doses were required to elicit early transient incapacitation. The ED_{50} for the gamma field was 2186 rads (midbrain tissue dose) and for the neutron field, 3215 rads. The difference between these two ED_{50}s was significant. The relative effectiveness for the neutron field in the study was 0.68 when compared to similar gamma exposures.

For early transient incapacitation, the relative effectiveness of similar neutron exposures was much lower for the miniature pigs (0.23) than for the monkeys (0.68). Also, in both studies (George et al. (4) and Thorp and Young (12)) the midthorax dose was higher for the gamma field than for the neutron, but the difference was less in the study using monkeys (12). This could be an important factor in reported differences for relative effectiveness. Dose rate differences have been considered as a possible variable in these two studies, but dose rate effects are generally attributed to relatively lower dose rates. The rates used by George et al. and Thorp and Young were beyond the general area of dose rate concern. Other attributable factors for the difference include differences in tasks or in animal species used. However, the conclusions for the above studies are still in the same direction--gamma exposures are more effective than similar neutron exposures for producing postirradiation performance decrements generally attributed to central nervous system disturbances.

The purpose of this study was to examine the effect of neutrons in order to better define dose levels and effects that might impact specific Air Force sorties, 24 and 48 hours postexposure. A review of the results from studies of gamma exposures led us to anticipate that the dose level selected for this study would produce moderate radiation effects as related to mission completion. The task and schedule arrangement 1) contained periods of moderately heavy workload (a correct response every 3 seconds), 2) had an uncomplicated arrangement between stimulus and response required, 3) allowed each subject to establish his own pace in operating the task, 4) permitted a significant shift or change in the pace (faster or slower) but with a response that could still be classified as correct, 5) had a moderately undesirable consequence (shock) for an incorrect response, and 6) had task length sufficient to produce mild fatigue (as a function of duration and workload).

METHODS AND PROCEDURES

Subjects

Eight male American-born rhesus (*Macaca mulatta*), ranging between 2.9 and 3.3 kg, were randomly selected from the USAF School of Aerospace Medicine (USAFSAM) colony and trained to operate the three-lever Multiple Avoidance Program (MAP), described in detail later.

Training--Each subject was individually hand trained by standard shaping techniques until performance was sufficiently stable for training to be taken over by laboratory programming equipment. Each subject was initially trained for approximately 1 hour per day. The shock level was approximately 3.0 mA for 0.3-second duration. When avoidance was consistent (95%) on the center lever, the other two levers were phased into the training regimen. Training sessions were gradually increased up to 4 hours (to match 4-h test sessions). Subjects were trained in 12-minute work periods followed by 3-minute rest periods. This cycle continued for all training and testing conditions.

Diet Control--At the beginning of each work period, each animal received a monkey biscuit, food pellets, and/or a small piece of fruit. This facilitated catching and restraining; it also simulated a subject with a small amount (snack) of food in the stomach. When returned to the home cage, each subject was fed a normal food ration. Feeding times were constant to facilitate observation for emesis during exposure. (See Table 1.)

Task

The MAP panel (Fig. 2) was located directly in front of the animal. When one of the red lights was lighted, the subject was allowed 3 seconds to press the lever directly below that light to extinguish it. Failure to press within

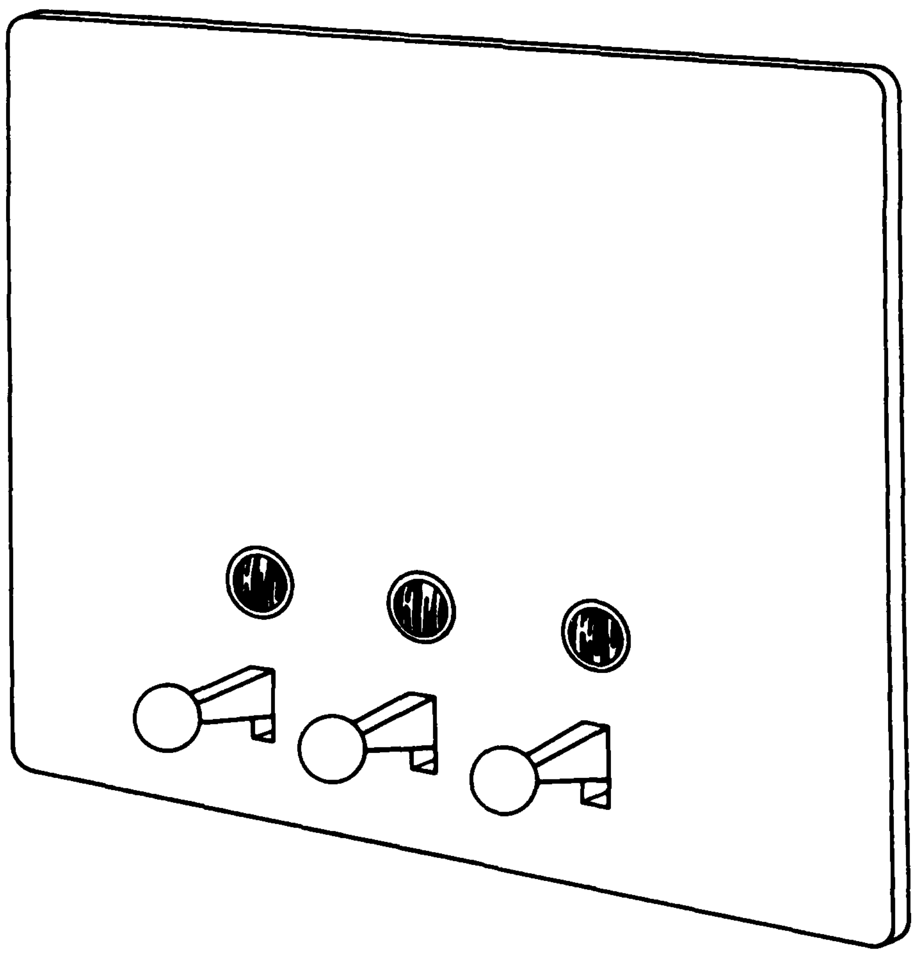

Figure 2. Animal response panel.

TABLE 1. SCHEDULE FOR TESTING AT WHITE SANDS MISSILE RANGE (WSMR)

Day 1	Travel to WSMR Set up equipment
Days 2,3	Rest days for animals
Days 4,5	Baseline testing 0700 - Feed snack to Group I 0800 - Begin subject baseline testing of Group I 1130 - Feed snack to Group II 1200 - Remove Group I Still-photograph Group I in cell Videotape individual animals Feed daily food ration to Group I 1230 - Begin subject baseline testing of Group II 1630 - Remove Group II Still-photograph Group II in cell Videotape individual animals Feed daily food ration to Group II
Day 6	Exposure day 0700 - Feed snack to Group I 0800 - Begin subject testing of Group I 0830 - Expose Group I 1130 - Feed snack to Group II 1200 - Remove Group I Note emetic activity Still-photograph Group I in cell Videotape individual animals Feed daily food ration to Group I 1230 - Begin subject testing of Group II 1300 - Expose Group II 1630 - Remove Group II Note emetic activity Still-photograph Group II in cell Videotape individual animals Feed daily food ration to Group II
Day 7	(24 hours post exposure) Repeat of Day 4
Day 8	(48 hours post exposure) Repeat of Day 4
Day 9	(72 hours post exposure) Repeat of Day 4
Day 10	Travel Return to Brooks AFB, Texas

3 seconds or pressing one of the two incorrect levers resulted in a small shock (2.0-3.0 mA) to the feet of the subject for 0.3 second. At the end of the 3-second response interval or when the subject pressed a lever, the lighted lamp was extinguished immediately and one of the other two was lighted. Thus, a stimulus cue lamp never repeated, and the speed of presentation was established by the animal as long as a response occurred within 3 seconds. Some subjects established work rates (set their own pace) of almost twice that of some other subjects.

Equipment

Each subject was placed in an individual cubicle (2'x3'x4') to minimize external distractions. The booth was power ventilated, and a small amount of light entered near the top-opening door.

All programming was done with Digibit equipment manufactured by BRS/LVE. The order of stimulus presentation was randomized in six balanced blocks of 24 trials per block, determined individually for each subject by a punched-papertape reader. This allowed each animal to work at his own pace.

Data was visually available for spot check on counters. Complete data was summarized each minute and dumped to punched papertape for backup. Identical data was simultaneously fed into a DEC MINC (11/23 computer) for recording on RX02 floppy disks. Collecting the data in machine readable format saved time in subsequent analysis. The immediate visibility was also useful in monitoring real-time performance and helped detect equipment problems during the course of testing.

Photography

All photography and video recording were done by White Sands Missile Range (WSMR) personnel. At the end of each work session the animals were still-photographed as a group before leaving the exposure cell. As soon as they were back in the holding cage, a 3-minute video recording was made of each animal. For some typical animals, the edited video recordings have been paired with the subject's performance for each day. The purpose was to compare the general appearance of the animal (which may be poor) and his performance scores (which may be near baseline levels).

Exposure Procedures

The eight subjects were always tested in two groups of four. Each group (morning or afternoon) was fed 1 hour before its work period started. See Table 1 for an account of daily activities.

The exposures occurred 30 minutes after the start of the work period, so 90 minutes had elapsed since the snack (1 biscuit and 1 orange slice) had been consumed. The small amount of food in an animal's stomach at the time of exposure was significantly less than the normal ration of 8-10 biscuits and 1 whole orange.

Dosimetry

The prime objective dosimetrically was to determine the exposure parameters required to deliver a midline total dose (neutron + gamma) of 600 rads to a 3.0-kg primate exposed in a training booth to the FBR (fast burst reactor) operating in the pulsed mode. The parameters were determined by dosimetric measurements in Alderson neutron tissue-equivalent plastic primate phantoms closely approximating the size of the subjects. On 28 and 29 May 1981, the phantom exposures were conducted in training booths identical with the ones used by the animals. Free-field measurements were also made.

The gamma dose component was measured with Harshaw-type 700 LiF thermoluminescent dosimeters (TLDs). The fast neutron dose component was measured with *dl-a*-alanine and sulfur foils. WSMR sulfur foils and TLDs and USAFSAM alanine and TLDs were run concurrently.

At 70 inches (178 cm) a midline total dose of 2.87 rads/^{o}C of reactor core temperature rise (ΔT_3) was obtained from the phantom exposure data. Based on this data, an exposure distance of 70 inches and a pulse size of 210^{o}C were chosen as the FBR operational parameters. A more complete description of dosimetric procedures and results is given in Appendix A.

Figure 3 shows the configuration used in the animal exposures. The animals were exposed (posterior to anterior) while seated in aluminum chairs inside the

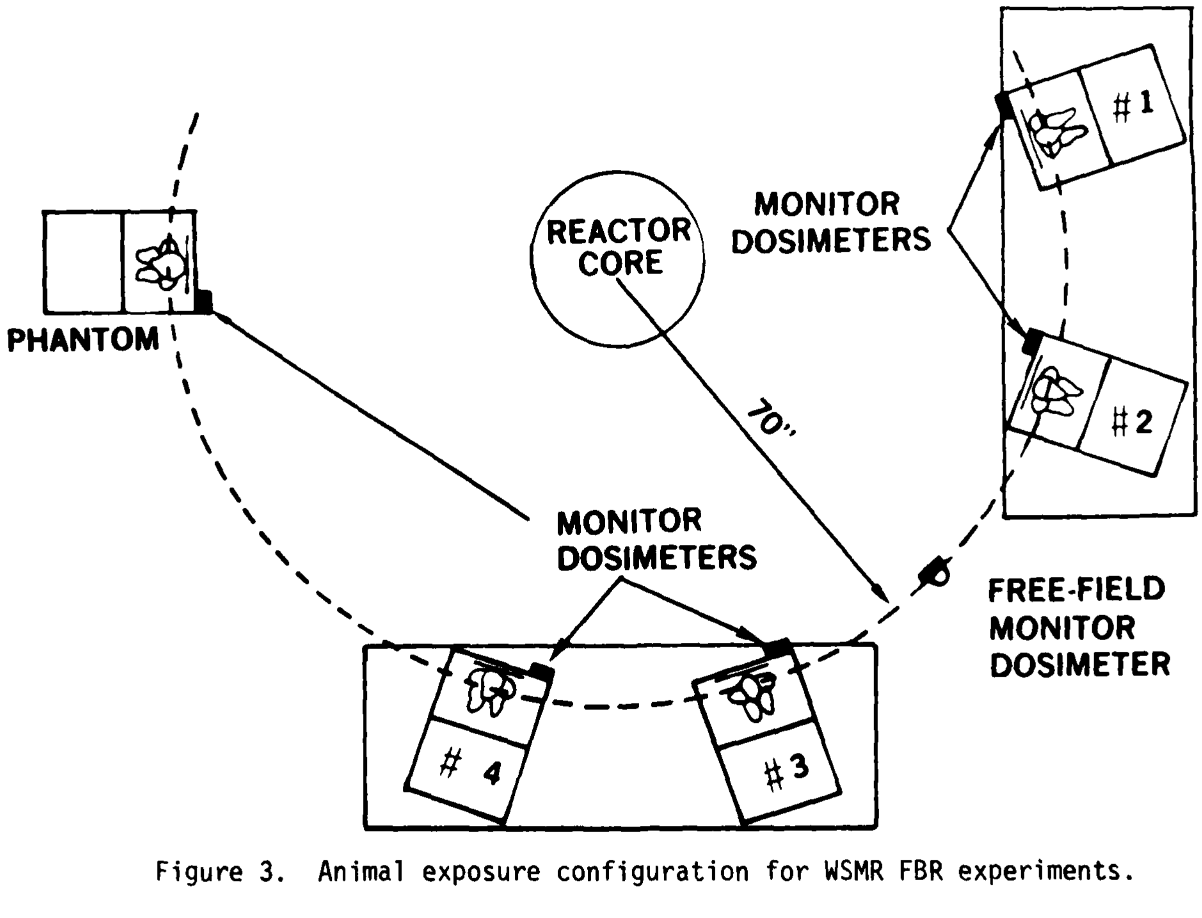

Figure 3. Animal exposure configuration for WSMR FBR experiments.

training booths. The booths were positioned on tables with the midpoint (solar plexus) level of the animals approximately 58 inches (147 cm) above the floor. The reactor core center was raised to this level such that the distance from source center to animal midline at the solar plexus level was 70 inches (178 cm). Monitor dosimeters were placed on the exterior of the aluminum back wall at animal midheight. Dosimeters were also exposed free-field at 70 inches at animal midheight. In addition, a dosimeter phantom was exposed with each group (as shown in Fig. 3). A pulse size of 210°C was required to deliver the desired total midline dose of 600 rads.

The animals were exposed on 22 July 1981 in two groups of four animals each, one group in the morning (Operation 9210) and one in the afternoon (Operation 9211). The actual pulse sizes obtained were 180°C and 220°C respectively. Table 2 lists the results of the booth-monitor dosimeters and the midline doses estimated therefrom for the animals and the phantoms exposed with them. This data indicates that the exposures within each group were reasonably uniform, with less than 5% variation about the average. Table 3 lists the dose values measured in the phantoms exposed with the animals. The data in Tables 2 and 3 indicate that the midline doses delivered to the animals in July were 3% to 5% higher than anticipated on the basis of the May phantom data (Table A-3). The neutron/gamma dose ratios obtained do not appear to be significantly different from the May values. Table 4 compares the entrance, midline, and exit doses predicted from the May phantom data with the doses measured in July in the

TABLE 2. MIDLINE DOSES ESTIMATED FROM BOOTH-MONITOR DOSES (WSMR FBR, 22 JULY 1981)

Dosimeter location	Animal ID*	Monitor dose (rads)	Est midline** dose (rads)
		OP 9210, Pulse size: 180°C	
Booth 1	184Z	820.2	533.1
Booth 2	176Z	814.6	529.4
Booth 3	180Z	822.3	534.5
Booth 4	178Z	795.4	517.0
Booth 5	Alderson phantom	827.7	538.0
		Average:	530.4 (± 8.1 SD)
		OP 9211, Pulse size: 220°C	
Booth 1	174Z	969.7	630.4
Booth 2	160Z	990.4	643.7
Booth 3	154Z	999.9	649.9
Booth 4	L64B	1041.0	676.7
Booth 5	Alderson phantom	1001.8	651.2
		Average:	650.4 (± 16.9 SD)

*Suffix designation will be deleted in following references to animal ID.
**Booth monitor dose X 0.65. (Midline doses estimated from ΔT_3 and May phantom data: 180°C X 2.87 rads/°C = 517 rads and 220°C X 2.87 rads/°C = 631 rads; see Table A-3.)

TABLE 3. RADIATION DOSES MEASURED IN PHANTOMS EXPOSED WITH ANIMALS (WSMR FBR, 22 JULY 1981)

Position (see Fig. A-2)	Gamma dose (D_G) (rads)	Neutron dose (D_N) (rads)	Total dose (rads)	N/G dose ratio
OP 9210, ΔT_3: +180°C				
		Posterior		
A	91.2	672.0	763.2	7.4
B	102.7	674.3	777.0	6.6
C	91.1	640.6	731.7	7.0
		Average:	757.3±23.2	7.0±0.4
		Midline		
D	70.1	438.7	508.8	6.3
F	86.0	503.2	589.2	5.9
H	89.4	424.6	514.0	4.7
I	86.4	484.9	571.3	5.6
		Average:	545.8±40.4	5.6±0.7
		Anterior		
J	62.5	243.9	306.6	3.9
K	70.7	165.5	236.2	2.3
L	75.7	205.5	281.2	2.7
		Average:	274.6±35.5	3.0±0.8
Free field (70")	79.7	627.7	707.4	7.9
Booth monitor	98.7	729.0	827.7	7.4
OP 9211, ΔT_3: +220°C				
		Posterior		
A	108.5	846	895.6	7.3
B	123.9	892	953.3	6.7
C	112.7	932	979.3	7.7
		Average:	942.7±42.8	7.2±0.5
		Midline		
D	80.5	472.3	552.8	5.9
F	109.7	591.0	700.7	5.4
G	95.9	557.5	653.4	5.8
H	99.8	548.0	647.8	5.5
I	107.7	621.1	728.8	5.8
		Average:	656.7±67.0	5.7±0.2
		Anterior		
J	71.8	229.7	301.5	3.2
K	87.2	279.9	367.1	3.2
L	90.2	306.9	397.1	3.4
		Average:	355.2±48.9	3.3±0.1
Free field (70")	98.3	776.8	875.1	7.9
Booth monitor	121.1	880.7	1001.8	7.3

TABLE 4. SUMMARY OF DOSIMETRY MEASUREMENTS OF PHANTOMS RUN SIMULTANEOUSLY WITH ANIMALS AT WSMR FBR, 22 JULY 1981, AS COMPARED TO DOSES PREDICTED FROM MAY PHANTOM EXPOSURES

Site	OP 9210 (ΔT_3 = 180°C)		OP 9211 (ΔT_3 = 220°C)	
	Dose	DN/DG	Dose	DN/DG
Posterior (entrance)				
Predicted	738	6.8	902	6.8
Measured	757	7.0	943	7.2
Midline				
Predicted	517	5.2	631	5.2
Measured	545	5.6	658	5.7
Anterior (exit)				
Predicted	261	2.9	319	2.9
Measured	275	3.0	355	3.3

phantoms exposed with the animals. In all cases, the July exposure doses are from 1% to 9% higher than the predicted values from the May data. The increase in dose may be due in part to increased scatter caused by having all five booths plus support tables in the field at the same time. The May phantom exposures were conducted with just one booth in the field at a time.

WSMR sulfur foils and USAFSAM alanine dosimeters, exposed concurrently during the animal exposures, were in agreement with respect to neutron dose to within 2% on the average for both reactor operations. Unfortunately, comparative TLD data was not available due to a breakdown in the WSMR TLD system.

RESULTS

Variables studied each day were accuracy (the number of errors) and correct-response times. Subjects performed on six occasions: two baseline runs; an exposure run; and 24-, 48-, and 72-hour postexposure followups. The first baseline was used to test equipment and allow subjects to adjust to their new surroundings. The second baseline was used as a standard against which each subject's performance could be judged on exposure and postexposure days.

Figure 4 shows the accuracy for each subject on each test day. The plot points represent 3-minute summaries. Subjects generally performed near 100% accuracy on the baseline run, as indicated by the overlapping of points at 1. Subject 6's poor score at the end of this run was the result of a burned-out light bulb.

On exposure day, the earliest accuracy decreases were noted at 9, 12, 15, and 27 minutes postexposure for subjects 4, 2, 3, and 7, respectively, with scores of 93%, 93%, 95%, and 96%. The performance of subjects 7 and 2 decreased the most; their accuracies were 88% and 90%, respectively, approximately 57 and

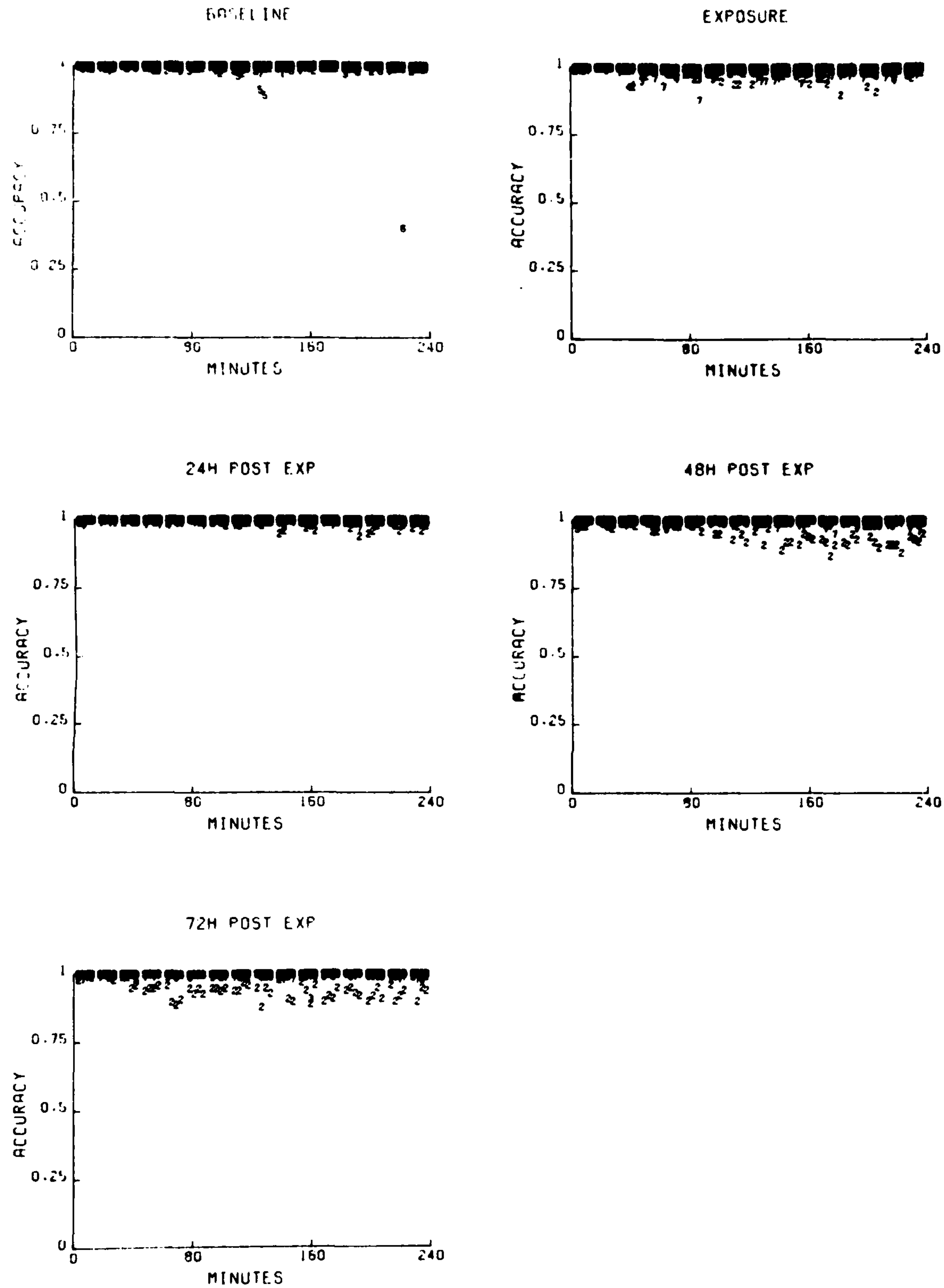

Figure 4. Five-day summary of accuracy scores. Subjects are numbered 1 through 8 and the scores are computed over 3-minute intervals. Dark spots indicate where subjects' performances overlap at 100% accuracy. The neutron pulse occurred at 30 minutes on exposure day.

153 minutes postexposure. Throughout the three postexposure test periods, these subjects had the greatest decreases in accuracy. At 24, 48, and 72 hours postexposure, subject 2's lowest accuracy scores were, respectively, 94%, 87%, and 88%, and subject 7's lowest scores were 97%, 95%, and 98%. Subject 2 consistently operated at these performance levels 48 and 72 hours postexposure, but subject 7's low scores were sporadic.

Understanding what a MAP accuracy represents will help place these performance scores in perspective. Table 5 summarizes the total number of errors made by each subject on each test day. These include both failing to respond and pressing the wrong response lever when a stimulus was presented. The last column gives the minimum and maximum number of presentations over the 5 test days. Subject 2's 286 errors at 72 hours postexposure were the most by any subject on any test day. These 286 errors occurred within 5167 presentations for that day: an accuracy of 94.5%. By most standards, a score of 94.5 is good. In this case, however, the subjects were highly trained and their accuracy rarely varied by more than 1-2%. The 286 errors represent a factor-of-6 increase in the number of errors made under baseline conditions for this subject--a substantial change in performance.

TABLE 5. PERFORMANCE ERRORS FOR 4-HOUR TEST PERIOD ON EACH TEST DAY

Subject--ID		Test Days: Baseline	Exposure	24 h post exposure	48 h post exposure	72 h post exposure	Trials/Day (min-max)
1	176	16	27	12	9	9	7526-8615
2	178	47	143	69	230	286	5091-6675
3	180	27	48	11	25	17	6407-8207
4	184	7	26	7	7	4	5832-7126
5	154	39	26	7	15	14	6883-8512
6	160	26*	10	13	5	2	8598-9992
7	L64	30	136	37	62	34	6358-7554
8	174	16	12	7	16	2	6953-8473
						Range:	5091-9992

*Baseline 1 was used because of a burned-out light bulb during the second baseline.

Table 6 illustrates the futility of comparing accuracy scores in this experiment. It compares accuracies during the half-hour of baseline performance with those during the half-hour of performance following the neutron pulse. It is one short of the seven subjects (with a decrease in accuracy) needed to show a statistically significant difference between these test periods by the sign test at the .05 level. If there had been this seventh subject, what could we conclude? We would have to say that the 0.5% difference in average accuracies 99.7% vs 99.2% was statistically significant, but in this case that "statistical" significance would not impact operational significance.

TABLE 6. COMPARISON OF ACCURACIES BETWEEN THE HALF-HOUR POSTEXPOSURE AND CORRESPONDING BASELINE HALF-HOUR

Subject	ID	% Accuracy: Exposure	% Accuracy: Baseline	% Change
1	176	99.4	99.9	- 0.5
2	178	98.4	99.8	- 1.4
3	180	99.0	99.3	- 0.3
4	184	98.4	99.9	- 1.5
5	154	99.6	99.9	- 0.3
6	160	100.0	99.0	+ 1.0
7	L64	99.0	99.8	- 0.8
8	174	100.0	99.9	+ 0.1
	Averages	99.2	99.7	

Contrasting the number of errors made is safer ground. A multiple comparison procedure based upon Friedman rank sums (7) detected no significant differences (at the .05 level) between test days for the total number of the errors shown in Table 5. Table 7 shows how the errors were distributed over the eight half-hour performance periods on exposure day. By the same test procedure and α-level, the total number of errors during the 2d, 3d, 5th, and 6th half hours after exposure were significantly greater than the number of errors commited during the half-hour before exposure.

TABLE 7. EXPOSURE-DAY ERRORS DISTRIBUTED ACROSS 8 HALF-HOUR TEST PERIODS

Subject	ID	Preexposure		Postexposure 1	2	3	4	5	6	7	Total errors
1	176	1	Pulse	5	5	5	2	3	4	2	27
2	178	2		14	15	25	20	23	28	16	143
3	180	1		8	9	9	5	5	6	5	48
4	184	0		14	3	1	2	2	1	3	26
5	154	0		3	1	2	2	7	7	4	26
6	160	0		0	1	2	0	0	6	1	10
7	L64	3		8	29	10	27	24	17	18	136
8	174	0		0	2	2	2	3	3	0	12
Total errors:		7		52	65*	56*	60	67*	72*	49	428

*Significant difference from preexposure period: α = .05, by equation 15, p. 151, Hollander and Wolfe (7)

Figure 5 shows the reaction times (in sec) for a correct response (using Fig. 4's labeling conventions). Appendix B contains a complete data summary. There is considerably more variability in this metric because each subject responds at his own pace within the 3-second response window. Under baseline conditions each subject's reaction times were generally linear and flat. Subjects 6 and 8 were the fastest responders; subjects 2 and 7 were the slowest. During the 30-minute preexposure period, the subjects' response patterns were generally similar to the preceding baselines. In particular, the scores were within the same ranges; they were linear; they were flat, with the exception of the scores of subjects 2 and 7 whose reaction times were decreasing (although they remained the slowest); and the subjects maintained their relative rankings, with subjects 6 and 8 the fastest.

Following the neutron pulse, reaction times slowly rose in all subjects (as did the variability in their reaction times) until new maximum reaction times were reached. Subject 7 was the first to exceed his maximum baseline reaction time, 27 minutes postexposure; and later that day his maximum became 1.88 seconds, a .51-second increase over his baseline maximum (1.37 sec). At 36 minutes subjects 1 and 2 exceeded their maximum baseline reaction times (1.17 and 1.49 sec, respectively). These subjects went on to achieve new maximum reaction times of 1.44 and 1.83 seconds; i.e., increases of .27 and .34 second. Subjects 3 and 6 exceeded their baseline maximums (1.49 and .96 sec respectively) at 42 and 51 minutes postexposure. Their new maximum reaction times were 1.82 and 1.17 seconds; i.e., increases of .33 and .21 second. Subject 8 followed next, exceeding his baseline maximum (.92 sec) at 69 minutes postexposure. His new high was 1.28 seconds, for a net maximum increase of .36 second. Subjects 4 and 5 were neither the fastest nor the slowest performers. Their baseline maximums of 1.3 and 1.1 seconds were increased to 1.49 and 1.39 seconds, respectively, at 102 and 63 minutes postexposure. These results are summarized in Table 8, also the percent of the time that exposure maximums exceeded baseline maximums. Statistically, by a sign test, the increase in maximum reaction times in eight of eight subjects is a significant event.

At 24 hours postexposure, responses were returning to baseline patterns. Subjects 6 and 8 were still the fastest responders, and 2 the slowest; subject 7 was being displaced upon occasion by subject 5 as a slower responder. For all subjects except number 2, responses had considerably less variability and were generally linear and flat.

TABLE 8. MAXIMUM REACTION TIME SUMMARY

Subject	ID	Baseline maximum (sec)	Exposure maximum (sec)	Net increase (sec)	Time (min) post-exposure when baseline maximum was first exceeded	% Time over baseline maximum
1	176	1.17	1.44	.27	36	30
2	178	1.49	1.83	.34	36	36
3	180	1.49	1.82	.33	42	2
4	184	1.30	1.49	.19	102	20
5	154	1.10	1.39	.29	63	41
6	160	.96	1.17	.21	51	13
7	L64	1.37	1.88	.51	27	48
8	174	.92	1.28	.36	69	27

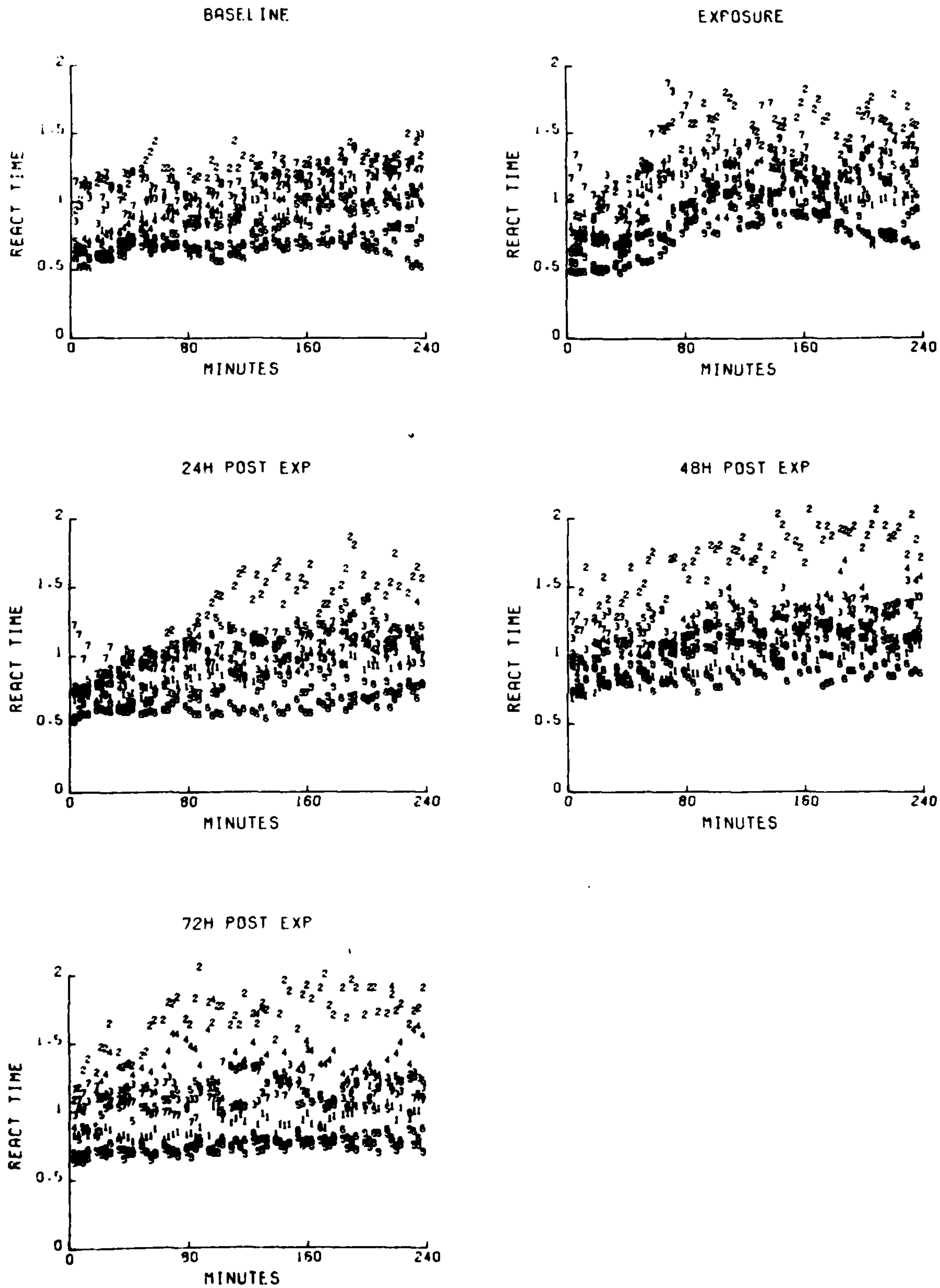

Figure 5. Five-day summary of reaction times (sec) for a correct response. Subjects are numbered 1 through 8, and the scores are computed over 3-minute intervals. The neutron pulse occurred at 30 minutes on exposure day.

At 48 hours postexposure, the responses were even less variable than on the preceding day. They were still linear and flat; subjects appeared to take longer to respond; and two changes occurred in subject rankings: Subject 1 displaced 8 as a faster responder, and subject 4 replaced 7 as a slower responder.

At 72 hours postexposure, reaction times were still longer than under baseline conditions. There was a greater separation between subjects, although performance was still linear and flat. Subject 4 continued to displace 7 as a slow responder (subject 2 was still the slowest), and subject 8 regained his position as a fast responder.

The average reaction time for the 4-hour test period on each test day is summarized for each subject in Table 9. The table depicts increased reaction times in most subjects: all eight on exposure day; five at 24 hours postexposure; all eight at 48 hours postexposure; and seven at 72 hours postexposure. Simultaneously comparing all test days with each other, using multiple comparison procedures based upon Friedman rank sums (7), leads to the conclusion that the average reaction times on exposure day and 48 hours postexposure were significantly longer than on the baseline day (α = .05). A more liberal procedure that compared all exposure and postexposure days versus the baseline day picked up no additional significant differences.

TABLE 9. AVERAGE REACTION TIMES (SEC) FOR 4-HOUR TEST PERIOD ON EACH TEST DAY

Subject	ID	Baseline	Exposure	24 h post	48 h post	72 h post
		Test Days				
1	176	.87	1.07	.87	.94	.91
2	178	1.24	1.44	1.31	1.72	1.68
3	180	1.12	1.16	.91	1.26	1.14
4	184	.94	1.09	1.00	1.25	1.35
5	154	.84	1.02	1.11	1.15	1.11
6	160	.58	.79	.60	.85	.77
7	L64	1.19	1.34	1.07	1.21	1.11
8	174	.69	.82	.75	1.02	.72

Each subject's reaction times were examined individually for radiation effects. The benefits of this approach is that it eliminates the "averaging out" of effects between subjects due to subject variability when reaction times might change. It also prevents averaging out effects within a given subject due to temporary excursions from his baseline behavior. The approach we apply is to first fit baseline behavior with a least-squares line and then construct the P = 0.95, α = 0.05 tolerance limits of Lieberman and Miller (8, 10) to identify a band of normal behavior about this line. Yochmowitz and Brown (13) first applied this approach to reaction-time experiments. The method requires time-independent data. The Durbin Watson test (11) indicated that this baseline data of 64 3-minute scores was serially correlated in time in many instances. Smoothing this data to sixteen 12-minute scores (i.e., the period the subjects worked between 3-min rests) led to six instances that were not correlated (as determined by the Durbin Watson test). Figure 6 shows these results. The least-squares

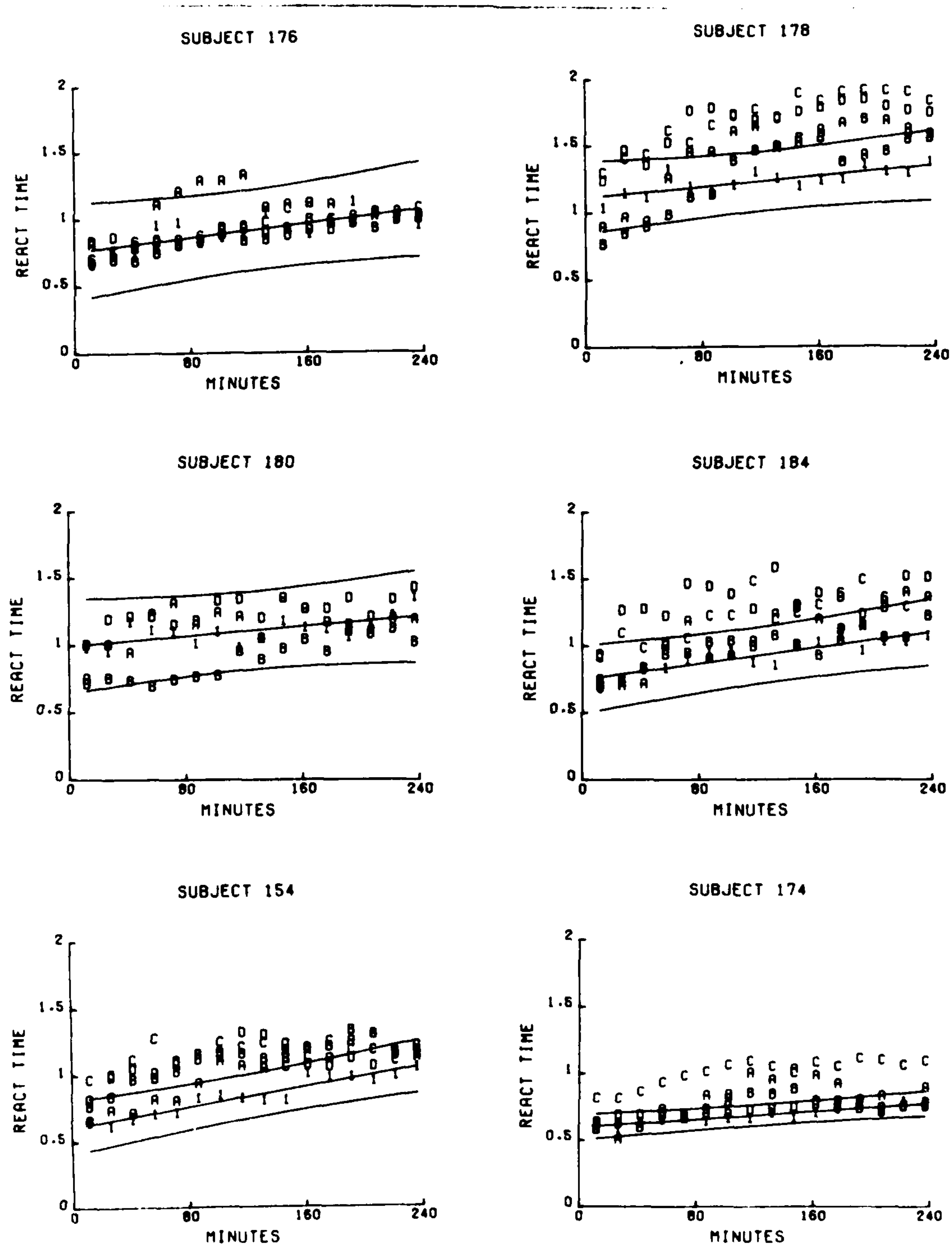

Figure 6. Summary of reaction times (sec) computed over 12-minute intervals. 1 represents baseline scores (reaction times); A, exposure day; B, C, and D, respectively, 24, 48, and 72 hours postexposure. A least-squares line was fit to the baseline scores and surrounded by P=.95, α=.05 simultaneous tolerance limits. Scores above the upper limit are judged to be longer than baseline reaction times by this criterion. The neutron pulse occurred at 30 minutes on exposure day.

line was fit to the baseline data points; the upper and lower limits correspond to the P = 0.95, $\alpha = 0.05$ criterion. Scores above the upper limit represent reaction times significantly longer by this criterion; similarly, reaction times below the lower limit would be judged significantly shorter.

By this criterion subjects had increased reaction times as follows: on exposure day--subjects 1, 2, 4, 5, and 8; 24 hours postexposure--subjects 2, 5, and 8; 48 hours postexposure--subjects 2, 4, 5, and 8; and 72 hours postexposure--subjects 2, 4, and 5. Subjects 6 and 7 were eliminated from this analysis because of the significance of the Durbin Watson test. On exposure day subject 7 had a maximum reaction time that exceeded baseline maximum time by .51 second. (See Table 8 for a summary.) The only other test day subject 7 exceeded the baseline maximum was the 48-hour postexposure test day, and then by .05 second. We therefore believe that subject 7's reaction times were significantly increased only on the exposure day. Also on exposure day, subject 6 had maximum reaction time that exceeded its baseline maximum by .21 second; none of its other test-day values exceeded the baseline maximum. We therefore believe that subject 6's reaction times were increased only on exposure day.

We conclude that of the eight subjects, seven had increased reaction times on exposure day; three at 24 hours postexposure; four at 48 hours postexposure, and three at 72 hours postexposure. All increases in reaction time on exposure day occurred after the pulse.

DISCUSSION

Neutron exposures at moderate dose levels (550-650 rads, 5.5:1 n/g ratio) can impair performance accuracy. The required task was rapidly paced, demanded high output, and was generally fatiguing; however, the "worst" individual baseline performance exceeded 99% accuracy (Table 6).

Parallels between the task loading of this study and parts of many operational aircrew tasks are not difficult to find. Many operational situations require bursts of activity followed by reduced work rates or short rests. An increase of 3 to 6 times the operator's normal (acceptable) error rate would likely have a negative effect on total mission performance (see Table 5 for our subjects). Many jobs have virtually no allowance for error. Refueling can permit limited errors up to a point, but an increased number of breakaways adds to total time required for this mission phase. Mission-essential subtasks have differing degrees of consequence for failure. One mistake in takeoff or landing on an aircraft carrier with a weapon-equipped plane can have profound consequences.

The subjects in this study performed their task at a high level of accuracy. Although performance accuracy did decrease for six of the eight subjects during the half-hour following exposure (Table 6), the decreases were actually very small. The average change from 99.7% to 99.2% correct is seemingly minor. However, on exposure day the number of errors before exposure increased significantly in four of the seven half-hour postexposure periods (Table 7). Every postexposure period had more errors than the preexposure period ($\alpha = .05$). Yet, if this relatively minor degradation of performance occurred in noncritical portions of a mission, such as high-altitude cruise, the effect would probably be negligible.

Response rate was significantly delayed after the 550- to 650-rad neutron exposure. Each subject established a particular pace or reaction time for performing the MAP. One feature of the task was that an animal could change his response rate (most averaged 1.0 sec) up to 3 seconds. Any response after 3 seconds was considered too late and the subject received a shock. By conservative methods of analysis, seven of the eight subjects had significantly increased reaction times on exposure day; three at 24 hours postexposure, four at 48 hours, and three at 72 hours. These subjects experienced minor loss of accuracy, but their reaction times were affected to a greater degree. The shift to slower correct responses is seen in Figure 5, also the increase in variability. A large biological variability is always associated with any animal study. The monkeys' accuracy in this study was very consistent and within fairly tight reaction-time limits. Although the animals were individually consistent, Figure 5 identifies subject 2 as being more variable than the others.

A shift in the range for reaction times tells us that the subject is not responding in an expected manner. His response ability has been degraded, if only slightly. Instead of being able to rigidly anticipate performance, we must now enlarge bounds of expected response.

Emetic response was another variable of interest. The animals were monitored for emesis at the end of the 4-hour postexposure work periods (Table 10). Six of the eight subjects had vomitus on their fur when removed from the work cubicle. Two of these six experienced an additional period of productive emetic behavior after return to the holding cage. All animals expressed little or no interest in food until about 8-9 hours postexposure. On the following days, the animals actively accepted their food but with obviously diminished interest.

TABLE 10. RADIATION EFFECTS

Subject	ID	Exposure day	Postexposure Days 24 h	48 h	72 h
1	176	A +			
2	178	A + E	A +	A +	A +
3	180	A E			
4	184	A + E		+	+
5	154	+ E	+	+	+
6	160	+			
7	L64	A + E	A	A	A
8	174	+ E	+	+	

A = Decreased accuracy defined by the presence of more errors on exposure and postexposure days than on the control baseline (as determined in Table 5)

+ = Increased reaction-time scores

E = Emesis within 3 1/2 hours postexposure

From the results presented here, no real loss in response accuracy and minimal loss in response time are easy to assume. However, although seemingly small, statistically significant performance changes in both areas were measured for most of the animals. We must conclude that any mission dependent upon a detailed and/or time-critical task would suffer some proficiency loss. How much loss would vary with the task and the time following exposure. Table 10 identifies another variable of radiation effects: a loss in one area of performance (e.g., accuracy) can occur with or without an accompanying degradation in another area (e.g., reaction time).

Even at 72 hours postexposure, most subjects were performing close to normal. The apparent lack of disastrous-performance consequences after this exposure must not mislead us. After the 72-hour postexposure test period, veterinary procedures were instituted for the treatment of radiation exposure. Supportive treatment measures included broad spectrum antibiotics, fluids (lactated Ringer's solution, 5% dextrose in water, and 50% dextrose solution), and multiple vitamin injections. However, on the eighth day, two animals died. Attending veterinary personnel reported that all animals were uniformly sluggish and retarded in activity level and appetite was increasingly depressed as time progressed. The two animals that died appeared similar to the others until approximately 1 hour prior to death, when they lay quietly on the cage bottom. Similar signs soon started to appear in the remaining six animals; they were euthanized a few hours later.

An element of risk always exists when we take animal data, regardless of how good, and make generalizations to human operational tasks. Without being specific for a particular task, however, these data can suggest some guidelines:

1) The 550- to 650-rad pulsed exposure dose of 5.5:1 n/g will impact both performance accuracy and reaction time.

2) For tasks without a low margin of error, performance can probably continue for several hours.

3) For a task with a critically low tolerance for error, performance may be significantly compromised. Aircraft-carrier-based flying personnel would be apt to perform below safe standards; landing on a carrier could very well be beyond an acceptable risk. At certain times after crew exposure, safety in land-based aircraft operations might be compromised, even in a normal takeoff procedure.

4) Twenty-four hours postexposure, personnel would likely be available for reuse; but by 48 hours postexposure, their speed of response for time-critical events would be affected.

5) Loitering should be possible for an extended period of time postexposure, even with minimal or perhaps no crew redundance.

6) Tasks required for penetration are very demanding and would be marginally affected 24 hours postexposure. After 48 hours, responses requiring speed would likely be jeopardized.

7) Refueling would probably be successful if an increased time element were possible. Additional breakaways would likely occur and lengthen the procedure. Again, activity at 24 hours postexposure would experience the least difficulty; after 72 hours, refueling would probably become much more difficult.

8) The cruise phase of missions would suffer the least radiation-related problems. Because of lowered work rates, crews should accomplish tasks with limited difficulty. The opportunity to spread activity out in time somewhat should increase the expected success rate, but this may not be possible in a tactical situation where activity is at a continuous high level.

9) As noted in Table 10, emetic activity, increased reaction time, and/or decreased accuracy may not coincide nor occur equally in all subjects.

The above hypotheses, or guidelines, are based mainly on this current study, with other studies serving as reference points. A building impression is that the neutron-exposed animals in this study were generally similar to animals exposed primarily to gamma radiation. However, the short-term recovery period after the early performance decrement casually appears to be longer for the neutron exposures than might be expected for a similar gamma exposure. To explore such relationship, it would be advisable to 1) expose a group of subjects at a higher neutron dose, and 2) using identical assessment methods, expose another group in a high-gamma, low-neutron dose. This approach would accomplish two objectives: 1) Higher neutron exposures (above the moderate 500- to 650-rad dose level in this study, where accuracy was minimally affected) would better identify a threshold for pronounced decrement in ability to respond correctly. 2) The gamma exposures would address the neutron relative biological effectiveness (RBE) question as presented by the work of George et al. (4) and Thorp (12). These were excellent studies, but a number of their differences may be minimized by use of identical techniques and animals. The RBE question becomes increasingly important with the most recent shift in the types of nuclear weapons being considered (6).

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APPENDIX A: DOSIMETRIC PROCEDURES AND RESULTS

Procedures

The initial step was to compare the USAFSAM dosimeter systems. On 7 Jan 1981 (Reactor Operations 8950) and 28-29 May 1981 (Reactor Operations 9153-9154), a series of USAFSAM dosimeters and WSMR TLDs and sulfur foils were exposed together, free-field, at varying distances from the reactor core.

The USAFSAM type 700 LiF powder thermoluminescent dosimeters were read on a Harshaw model 2000 TL Analyzer at USAFSAM. Gamma doses were assigned by comparing responses of the dosimeters exposed at WSMR with responses of a calibrated set of TLDs from the same lot that had been irradiated at USAFSAM to gamma rays from an AECL Eldorado 78 Co-60 source with output calibration traceable to NBS. The TLD powder was encapsulated in #5 gelatin capsules, which in both cases were exposed in Plexiglas tubing of 0.5 g/cm^3 wall thickness. The fast neutron response of the TLD material exposed free-field is assumed to be negligible. Table A-1 compares the gamma doses of the 7 Jan 1981 exposure. Similar comparison could not be made of the May exposure because of WSMR dosimeter system failure.

TABLE A-1. GAMMA DOSES MEASURED FREE-FIELD AT WSMR FBR ON 7 Jan 1981

Distance (in)	WSMR (rads tissue)	USAFSAM (rads tissue)
55	158.4	160.3
70	100.4	97.3
90	68.9	70.3
110	49.8	47.6
140	32.4	31.1
66*	117.1	116.9

*Monitor at back of training booth

The *dl-α*-alanine measures both the fast-neutron and gamma-dose components. The *dl-α*-alanine dosimeter responses were measured on a Varian Associates model E-6 Electron Paramagnetic Resonance Spectrometer. The peak amplitude of the radiation-induced free radical resonance spectrum was used as the response. An equivalent dose (D_A) was then assigned to the response of the FBR experimental dosimeter by comparing its response with that of a calibrated set of Co-60 gamma dosimeters exposed at USAFSAM. To determine the neutron dose component, the following empirical equation was used:

$$D_N = N(D_A - D_G)$$

where: D_N = neutron dose in rads tissue

N = fast neutron dose conversion factor

D_A = Co-60 equivalent dose in rads tissue as determined from alanine response

D_G = gamma dose in rads as determined from type 700 LiF TLD responses.

One dosimetric objective was to establish the fast neutron dose conversion factor (N) for the WSMR spectrum. The fast neutron dose was determined from the fast neutron fluence measured with sulfur foils exposed at the same time as the USAFSAM dosimeters, by WSMR. The sulfur fluence was converted to rads tissue by application of a spectral multiplication factor of 6.7 and a rads per n/cm^2 conversion factor of 2.5 X 10^9. This procedure put the USAFSAM alanine neutron dosimetry system in line with currently accepted dosimetric values at WSMR. Table A-2 lists the results of this determination for the series of intercomparisons performed in January and May 1981. The average value for N was 2.44 (± 0.11 SD). This neutron dose conversion factor was used in the subsequent phantom measurements.

TABLE A-2. DETERMINATION OF FAST NEUTRON DOSE CONVERSION FACTOR (N) FOR *DL-A*-ALANINE MEASURED AT WSMR FBR

Sample	Total fast neutron fluence (Ø)*	Neutron dose (D_N)** (rads)	Gamma dose (D_G) (rads)	D_A*** (rads)	D_A-D_G (rads)	N
7 Jan 81						
55" Free Field	42.9X10^{10}n/cm^2	1073.6	160.3	591.3	431.0	2.49
70" Free Field	25.5X10^{10}n/cm^2	638.1	97.3	360.0	262.7	2.43
90" Free Field	16.6X10^{10}n/cm^2	415.0	70.3	241.5	171.2	2.42
110" Free Field	11.2X10^{10}n/cm^2	279.6	47.6	164.5	116.9	2.39
140" Free Field	7.0X10^{10}n/cm^2	174.2	31.1	95.6	64.5	2.70
Booth Monitor	33.4X10^{10}n/cm^2	834.2	116.9	432.7	315.9	2.64
28 May 81						
50" Free Field	57.1X10^{10}n/cm^2	1428.4	160.0	768.0	608.0	2.34
70" Free Field	29.9X10^{10}n/cm^2	746.3	94.0	401.0	307.0	2.43
90" Free Field	17.7X10^{10}n/cm^2	442.0	60.7	247.0	186.3	2.37
Booth Monitor	31.6X10^{10}n/cm^2	790.9	106.6	441.0	334.4	2.36
29 May 81						
70" Free Field	31.8X10^{10}n/cm^2	795.6	101.5	437.0	335.5	2.37
110" Free Field	12.9X10^{10}n/cm^2	323.0	52.5	186.5	134.0	2.41
Booth Monitor	34.4X10^{10}n/cm^2	860.8	117.5	482.8	365.6	2.35
					Average:	2.44 (±0.11 SD)

*Sulfur foil fluence X 6.7

**D_N = Ø (n/cm^2) X 2.5 X 10^{-9} rads/(n/cm^2)

***D_A = Co-60 equivalent dose as determined from alanine response

Figure A-1 illustrates the results of the free-field measurements as a function of distance from the reactor core center. The dose values are presented in rads/°C of reactor core temperature rise (ΔT_3).

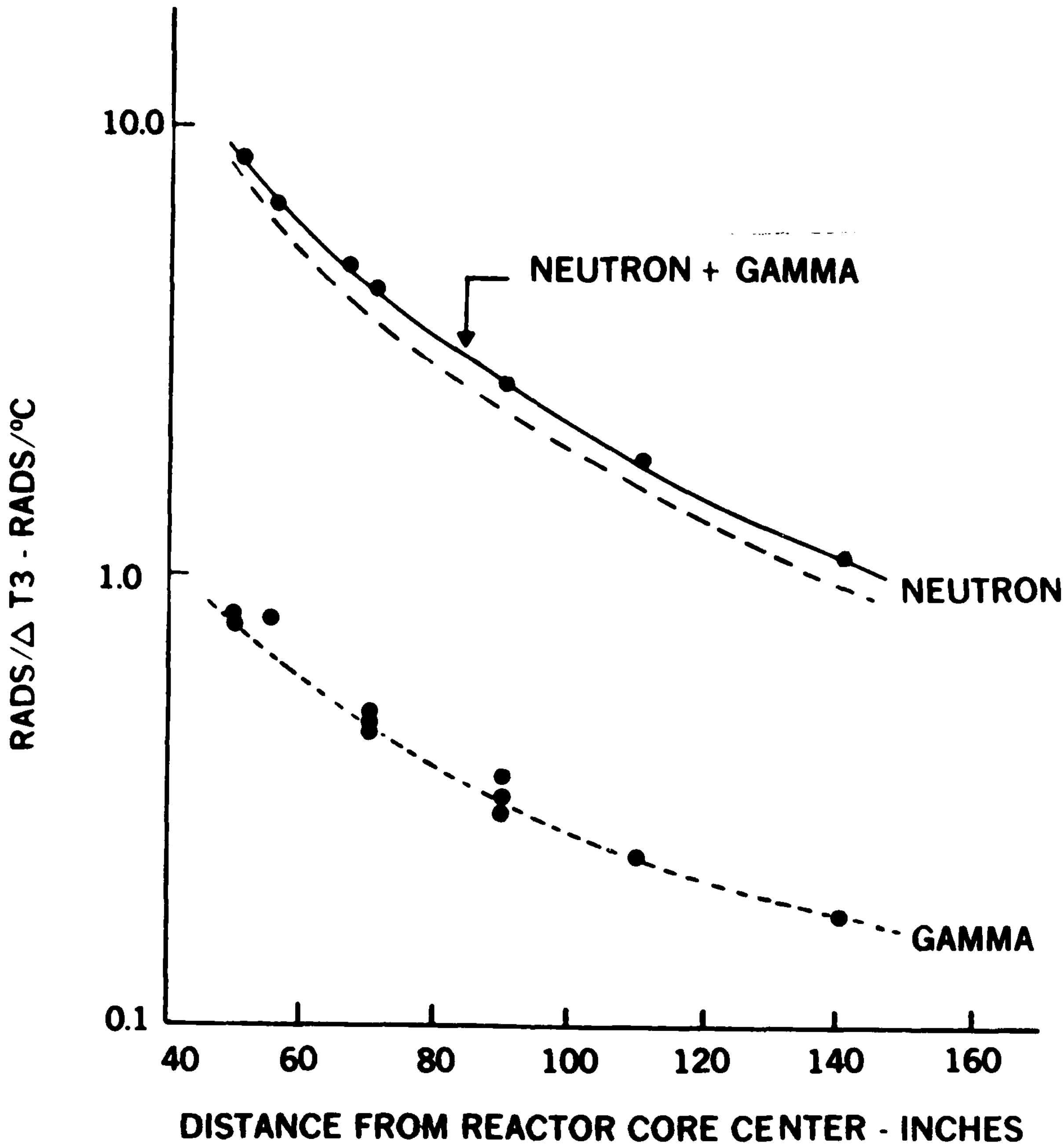

Figure A-1. Free-field dose--core temperature ratio vs distance measured at WSMR FBR.

The primary phantom measurements were conducted on 28 and 29 May. Two phantoms were separately exposed posterior-anterior in training booths identical with those used by the animals. The phantoms were seated in aluminum primate holding chairs. The back (radiation entrance) side of the booth is 0.063-inch-thick (1.6 mm) aluminum sheeting. The rest of the booth is made of 5/8-inch (16 mm) plywood. An instrument panel constructed primarily of Plexiglas is in front of the phantom/animal. Figure A-2 illustrates the phantom exposure configuration and the location of the points where the dosimetric measurements were made. The distance from phantom midline to reactor core center was 70 inches (178 cm). This distance was selected on the basis of previous dosimetric data obtained in weapons effects experiments at WSMR in the late 1960's. The reactor pulse size obtained on 28 May (Operation 9153) was 204°C. The pulse size on 29 May (Operation 9154) was 219°C. Type 700 LiF TLD powder was used in the gamma measurements. For TL dosimeters implanted in the midline of the phantom, special dosimeter holders containing Li-6-enriched TLD powder shields approximately 1 mm thick were used to eliminate overresponse due to thermal neutron contamination in the phantom. Comparative measurements with Co-60 gamma rays, using the Li-6 shields and the standard Plexiglas shields, gave a difference in response of less than 1%. Inside the phantom, in mixed neutron-gamma fields, the non-Li-6-shielded TLDs gave doses on the order of 50% higher than the Li-6-shielded dosimeters due to the effects of thermal neutrons. The difference

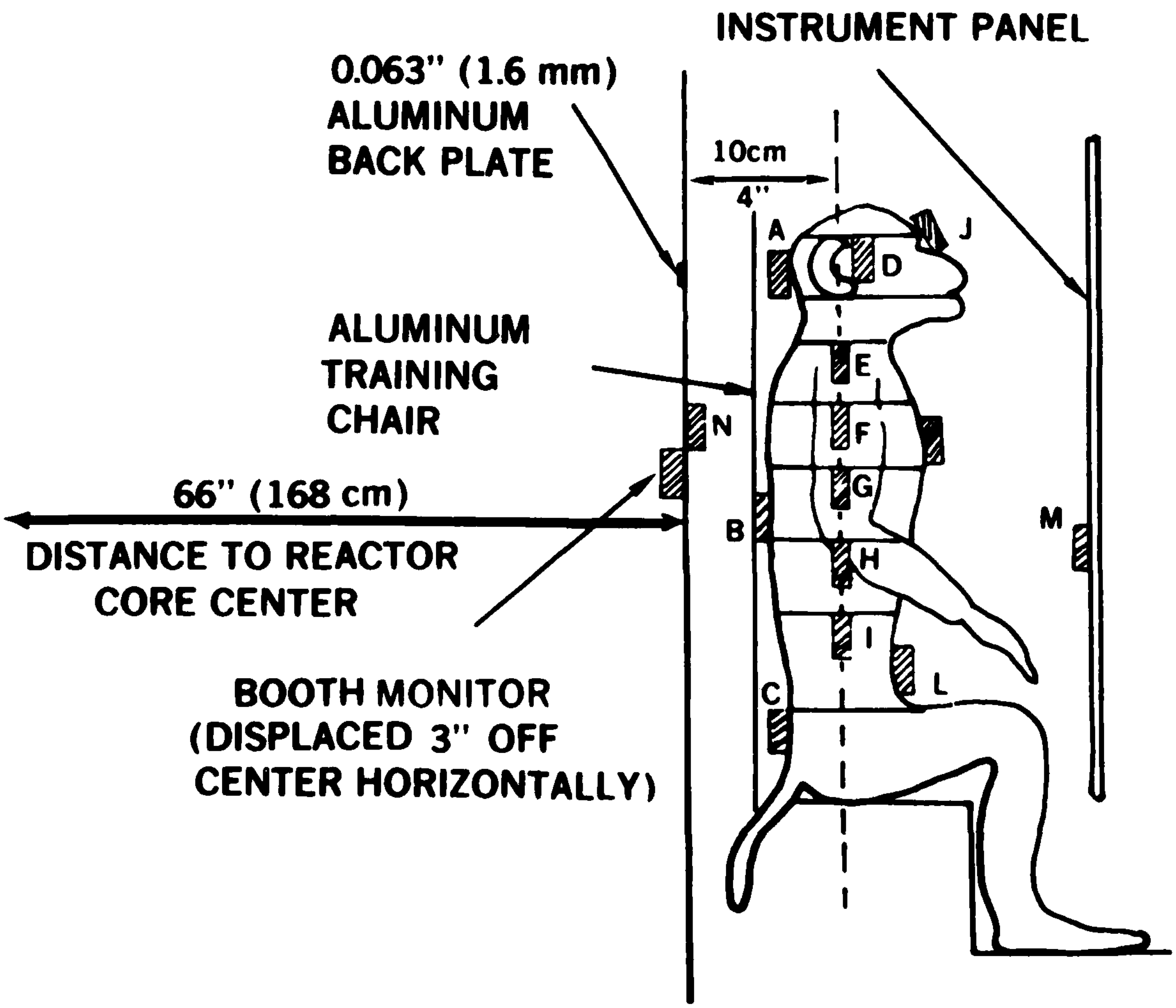

Figure A-2. Exposure configuration for phantom dosimetric measurements at WSMR FBR, May and July 1981.

in dose between the Li-6-shielded and non-Li-6-shielded dosimeters was on the order of 5-7% in the free-field environment and 10-12% on the exterior of the phantom. In this report non-Li-6-shielded doses are used in the free-field and external-phantom measurements. For the internal (midline) doses, the values obtained from Li-6-shielded dosimeters are used.

DL-α-alanine was used to measure the neutron doses. The alanine powder was initially encapsulated in type 0 gelatin capsules. In the free-field and external-phantom measurements, the alanine capsules were enclosed in 0.5-g/cm^2-wall-thickness Plexiglas tubes. No special shielding was used for the midline dose measurements as the alanine was assumed to be relatively insensitive to thermal neutrons.

Results

The results of the phantom dosimetric measurements are presented in Table A-3. As in the free-field data, the results are given in rads/^{0}C of reactor-core temperature rise. At 70 inches (178 cm) the phantom posterior (entrance), midline, and anterior (exit) dose values were 4.10 ($\pm$ 0.25 SD), 2.87 ($\pm$ 0.29 SD), and 1.45 ($\pm$ 0.19 SD) rads/^{0}C respectively. Thus, for a 210^{0}C pulse, the entrance, midline, and exit doses should be approximately 860, 603, and 305 rads respectively. On this basis, 210^{0}C was chosen to be the required pulse size. The neutron/gamma dose ratios were 6.8, 5.2, and 2.9 respectively. The free-field and booth-monitor doses were 4.11 and 4.44 rads/^{0}C; the neutron/gamma dose ratios were 7.9 and 7.4 respectively. From this, the midline dose was determined to be approximately 0.7 and 0.65 X the free-field and booth-monitor dosages respectively. The dosimeter placed on the inside of the aluminum back wall (position N) gave doses essentially the same as the dosimeters outside the booth--indicating little, if any, effect by the aluminum back plate.

All dosimeters were read out at least twice, on separate dates. When a significant difference was seen, a third series of readings were taken. Each TLD dose represents at least 12 readings ($\sim$ 6 per date), or 18 readings where a third readout was required. The alanine dosimeters were each scanned approximately five times on each readout date.

Dosimetry Summary

On 22 July 1981, two groups of primates, four animals to each group, were exposed (in separate operations, 9210 and 9211) on the WSMR FBR operating in the pulsed mode (pulse width: 50 μsec at full width-half maximum). The animals were exposed posterior-anterior in training booths at 70 inches (178 cm) distance from animal midline to reactor core center. The required reactor pulse size was 210^{0}C for a midline dose of 600 rads (based on the May phantom dosimetric measurements). The actual pulse sizes obtained were 180^{0}C and 220^{0}C. Based on the May calibration data, the midline doses were estimated to be approximately 550 and 650 rads respectively.

Monitor dosimeters on the animal booths and phantom dosimeters, exposed simultaneously, indicated that the average midline doses delivered were in the order of 530-545 rads and 650-655 rads respectively--3-5% higher than anticipated from the May data (see Tables 2 and 3). This difference could be due, in part, to increased scatter from adjacent booths and support tables. The observed free-field and midline neutron/gamma dose ratios were 7.9 and 5.7, respectively (essentially the same as those obtained in the May phantom studies); the entrance and exit neutron/gamma dose ratios were approximately 7.1 and 3.2.

TABLE A-3. RESULTS OF MAY 1981 PHANTOM DOSIMETRIC MEASUREMENTS AT WSMR FBR

Operation	Dosimeter location (Fig. A-2)	D_G (rads)	D_N (rads)	Total dose (rads)	Rads/ ΔT_3	D_N/D_G ratio
	Back of Booth					
9153	Booth monitor	106.6	791	897.6	4.40	7.4
9153	N	106.0	801	907.0	4.45	7.6
9154	Booth monitor	117.5	860	978.3	4.47	7.3
				Average:	4.44±0.04	7.4±0.2
	Free Field					
9153	70"	94.0	746	840.0	4.12	7.9
9154	70"	101.5	796	897.5	4.10	7.8
				Average:	4.11	7.9
	Phantom Posterior					
9153	A	102.8	740	842.8	4.13	7.2
9154	A	117.0	799	916.0	4.18	6.8
9153	B	113.3	727	840.3	4.12	6.4
9154	B	120.3	865	985.3	4.50	7.2
9153	C	100.4	689	789.4	3.87	6.9
9154	C	114.3	722	836.3	3.81	6.3
				Average:	4.10±0.25	6.8±0.4
	Phantom Midline					
9153	D	77.7	530	607.7	2.98	6.8
9154	D	83.8	473	556.8	2.54	5.6
9153	E	96.2	511	607.2	2.98	5.3
9153	F	96.2	494	590.2	2.89	5.1
9154	F	106.2	616	722.2	3.29	5.8
9154	G	107.2	434	541.2	2.47	4.0
9153	H	102.0	446	548.0	2.69	4.4
9154	H	108.1	486	594.1	2.71	4.5
9153	I	94.3	483	577.3	2.82	5.1
9154	I	106.7	623	729.7	3.33	5.8
				Average:	2.87±0.29	5.2±0.8
	Phantom Anterior					
9154	J	79.0	265	344.0	1.57	3.4
9153	K	71.2	189	260.2	1.28	2.7
9154	K	80.0	190	270.0	1.23	2.4
9153	L	77.4	267	344.4	1.69	3.4
9154	L	86.5	234	320.5	1.46	2.7
				Average:	1.45±0.19	2.9±0.5
	Console					
9154	M	67.3	150	217.3	0.99	2.2

APPENDIX B

THREE-MINUTE AVERAGE REACTION TIME AND ACCURACY SCORES

(******** = missing data point)

EXPOSURE TO: 550 & 650 NEUTRON PULSE

SUBJECT 176 VARIABLE ACCURACY

WORK SESSION	RUN BASELINE	EXPOSURE	24 POST	48 POST	72 POST
1	1.000	1.000	1.000	0.990	1.000
2	1.000	1.000	1.000	1.000	1.000
3	1.000	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000
7	1.000	0.990	1.000	1.000	0.990
8	1.000	1.000	0.990	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000
10	0.990	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000
13	1.000	0.980	1.000	1.000	1.000
14	1.000	0.990	1.000	1.000	1.000
15	1.000	0.990	1.000	0.990	1.000
16	1.000	0.990	1.000	1.000	1.000
17	1.000	1.000	1.000	1.000	1.000
18	1.000	0.990	1.000	1.000	1.000
19	0.990	0.990	1.000	1.000	1.000
20	0.990	1.000	0.990	1.000	1.000
21	1.000	1.000	1.000	0.990	1.000
22	1.000	0.980	1.000	1.000	1.000
23	1.000	1.000	1.000	1.000	1.000
24	1.000	0.990	1.000	1.000	1.000
25	1.000	0.980	1.000	1.000	1.000
26	0.980	0.990	1.000	1.000	1.000
27	1.000	1.000	1.000	1.000	1.000
28	1.000	0.990	0.990	1.000	1.000
29	1.000	1.000	0.990	1.000	1.000
30	1.000	1.000	0.990	1.000	0.990
31	1.000	1.000	1.000	1.000	1.000
32	1.000	0.990	1.000	1.000	0.990
33	1.000	0.990	1.000	1.000	1.000
34	1.000	0.990	1.000	1.000	1.000
35	*********	1.000	1.000	1.000	0.990
36	1.000	1.000	1.000	1.000	1.000
37	1.000	1.000	1.000	1.000	1.000
38	0.970	1.000	1.000	1.000	1.000
39	1.000	1.000	1.000	1.000	1.000
40	1.000	1.000	1.000	1.000	1.000
41	0.980	0.990	0.990	0.990	1.000
42	1.000	0.990	1.000	0.990	1.000
43	1.000	1.000	1.000	0.990	1.000
44	1.000	1.000	1.000	1.000	1.000
45	1.000	1.000	0.990	1.000	1.000
46	1.000	0.990	1.000	1.000	1.000
47	1.000	1.000	1.000	1.000	0.990
48	1.000	1.000	1.000	1.000	1.000
49	1.000	0.980	1.000	0.990	1.000
50	0.990	1.000	0.990	1.000	1.000
51	1.000	1.000	0.990	1.000	1.000
52	1.000	1.000	1.000	1.000	1.000
53	1.000	1.000	1.000	1.000	1.000
54	0.990	1.000	1.000	0.980	0.990
55	*********	0.980	1.000	1.000	1.000
56	*********	1.000	1.000	1.000	1.000
57	0.990	1.000	1.000	1.000	0.990
58	1.000	1.000	0.990	1.000	0.990
59	1.000	1.000	1.000	1.000	1.000
60	1.000	0.990	1.000	1.000	1.000
61	1.000	1.000	0.990	1.000	1.000
62	0.990	1.000	1.000	1.000	1.000
63	1.000	1.000	1.000	1.000	1.000
64	1.000	0.990	0.990	1.000	0.990

SUBJECT 176 VARIABLE REACT TIME

WORK SESSION	BASELINE	EXPOSURE	24 POST	48 POST	72 POST
	RUN				
1	0.650	0.820	0.680	0.690	0.830
2	0.670	0.770	0.690	0.720	0.840
3	0.660	0.800	0.660	0.720	0.860
4	0.690	0.920	0.710	0.710	0.830
5	0.730	0.800	0.670	0.730	0.840
6	0.790	0.700	0.690	0.770	0.860
7	0.770	0.710	0.720	0.830	0.890
8	0.750	0.690	0.700	0.780	0.870
9	0.780	1.130	0.650	0.810	0.820
10	0.710	0.740	0.720	0.840	0.830
11	0.760	0.720	0.660	0.870	0.810
12	0.740	0.660	0.730	0.830	0.780
13	0.910	1.070	0.690	0.770	0.820
14	1.010	1.130	0.770	0.880	0.810
15	1.050	1.110	0.790	0.870	0.820
16	0.890	1.150	0.760	0.850	0.870
17	1.010	1.160	0.790	0.830	0.790
18	0.890	1.250	0.820	0.830	0.810
19	0.950	1.220	0.830	0.860	0.830
20	1.080	1.190	0.800	0.890	0.850
21	0.800	1.210	0.780	0.870	0.830
22	0.840	1.290	0.840	0.920	0.840
23	0.840	1.380	0.920	0.870	0.810
24	0.830	1.310	0.850	0.870	0.880
25	0.830	1.380	0.920	0.900	0.820
26	0.920	1.340	0.890	0.920	1.020
27	0.860	1.190	0.920	0.950	0.990
28	0.900	1.260	0.860	0.890	0.940
29	0.790	1.290	0.890	0.900	0.910
30	0.890	1.310	0.880	1.000	0.940
31	0.920	1.440	0.830	0.920	0.970
32	0.980	1.270	0.790	0.980	0.920
33	1.010	1.220	0.810	0.940	0.820
34	1.130	1.100	0.830	0.920	0.900
35	********	1.030	0.870	1.080	0.980
36	0.950	1.020	0.910	0.980	0.950
37	1.040	1.070	0.890	0.950	0.830
38	0.890	1.070	0.940	1.110	0.900
39	0.890	1.080	0.970	1.090	0.890
40	0.930	1.230	0.910	1.170	0.900
41	0.910	1.250	0.970	1.090	0.850
42	0.830	1.000	0.990	1.130	0.930
43	0.860	1.090	1.000	1.180	0.980
44	0.940	1.140	1.040	1.080	0.900
45	0.930	1.220	0.990	0.970	0.890
46	1.070	1.020	0.990	1.020	0.870
47	1.040	1.090	0.920	1.010	0.940
48	0.980	1.120	1.000	1.000	0.960
49	1.110	1.020	0.950	0.980	0.970
50	1.160	1.000	0.940	1.000	0.980
51	1.070	1.020	1.010	1.060	0.980
52	1.170	1.030	1.000	1.040	1.030
53	0.950	1.020	0.900	1.000	1.000
54	1.080	1.030	0.940	1.060	1.180
55	********	1.060	0.930	1.030	1.030
56	********	0.980	0.930	1.050	1.010
57	1.030	1.020	1.010	0.950	1.060
58	1.030	1.030	0.910	0.980	1.030
59	0.990	1.140	1.110	1.050	0.930
60	1.020	1.000	0.930	1.130	1.020
61	0.970	1.000	0.980	1.020	0.940
62	0.980	1.050	1.080	1.100	1.000
63	0.860	1.020	1.050	1.110	1.000
64	0.980	0.950	0.990	1.080	1.100

SUBJECT 178 VARIABLE ACCURACY

WORK SESSION	RUN BASELINE	EXPOSURE	24 POST	48 POST	72 POST
1	1.000	0.990	0.990	1.000	0.980
2	1.000	1.000	0.990	1.000	1.000
3	1.000	0.990	1.000	0.980	1.000
4	0.990	1.000	1.000	1.000	0.990
5	1.000	1.000	1.000	1.000	1.000
6	0.990	1.000	1.000	0.990	1.000
7	0.990	1.000	1.000	0.980	0.990
8	1.000	1.000	1.000	0.970	0.980
9	1.000	1.000	0.990	0.990	0.990
10	0.990	0.990	1.000	1.000	0.990
11	1.000	0.990	1.000	1.000	0.950
12	1.000	0.930	1.000	0.980	0.960
13	1.000	1.000	1.000	1.000	0.940
14	1.000	0.970	1.000	0.990	0.950
15	0.990	1.000	0.990	0.960	0.950
16	1.000	0.990	1.000	0.960	0.960
17	0.980	1.000	0.990	0.990	0.960
18	0.990	0.980	1.000	1.000	0.900
19	0.990	0.980	0.990	0.980	0.890
20	1.000	0.970	1.000	0.980	0.910
21	1.000	0.980	1.000	0.990	0.950
22	0.990	0.990	1.000	0.980	0.930
23	0.990	0.960	1.000	0.990	0.950
24	0.990	0.990	0.990	0.960	0.930
25	1.000	0.980	0.990	1.000	0.950
26	0.990	0.980	1.000	0.950	0.950
27	0.970	0.970	0.990	0.950	0.940
28	1.000	0.950	0.980	1.000	0.950
29	1.000	0.980	1.000	0.930	0.940
30	0.990	0.940	0.980	0.980	0.940
31	0.970	0.940	0.990	0.950	0.970
32	0.990	0.980	0.990	0.920	0.960
33	0.980	0.940	1.000	0.960	0.950
34	0.990	0.990	0.980	0.990	0.880
35	0.990	0.970	0.990	0.910	0.950
36	0.990	0.990	1.000	0.970	0.930
37	0.990	0.980	0.950	0.990	0.980
38	1.000	0.980	0.960	0.890	0.990
39	0.990	0.970	1.000	0.920	0.910
40	1.000	0.980	1.000	0.920	0.900
41	0.990	0.990	0.990	0.910	0.970
42	1.000	0.980	0.970	0.950	0.940
43	1.000	0.960	0.980	0.940	0.890
44	0.980	0.940	0.960	0.930	0.960
45	0.990	0.960	1.000	0.930	0.900
46	0.990	0.960	1.000	0.920	0.920
47	0.990	0.940	1.000	0.870	0.910
48	0.990	0.990	1.000	0.910	0.950
49	1.000	0.900	0.990	0.920	0.940
50	1.000	0.990	0.970	0.910	0.950
51	1.000	0.990	0.990	0.950	0.930
52	0.980	0.990	0.940	0.930	0.920
53	1.000	0.990	0.950	0.980	0.900
54	0.980	0.930	0.960	0.940	0.920
55	1.000	0.980	0.980	0.920	0.950
56	1.000	0.910	1.000	0.900	0.910
57	0.990	0.990	1.000	0.910	0.960
58	0.990	0.990	0.980	0.910	0.900
59	1.000	0.960	0.960	0.910	0.920
60	0.990	0.990	0.990	0.880	0.940
61	0.980	0.970	0.970	0.940	0.990
62	0.990	0.960	0.990	0.930	0.900
63	0.990	0.990	0.960	0.920	0.950
64	0.990	0.980	0.980	0.950	0.940

SUBJECT 178 VARIABLE REACT TIME

WORK SESSION	BASELINE	EXPOSURE	24 POST	48 POST	72 POST
	RUN				
1	0.940	1.030	0.780	1.020	1.090
2	1.020	0.900	0.760	1.200	1.180
3	1.130	0.890	0.770	1.470	1.310
4	1.090	0.800	0.770	1.650	1.390
5	1.140	0.890	0.800	1.280	1.290
6	1.170	0.970	0.840	1.370	1.480
7	1.160	0.950	0.870	1.580	1.470
8	1.120	1.100	0.910	1.420	1.650
9	1.100	1.080	0.870	1.290	1.440
10	1.040	0.900	0.840	1.390	1.330
11	1.130	0.700	0.940	1.450	1.350
12	1.220	1.170	0.960	1.650	1.340
13	1.240	1.190	0.950	1.470	1.410
14	1.300	1.300	1.030	1.530	1.440
15	1.360	1.280	0.980	1.700	1.630
16	1.440	1.260	1.010	1.760	1.670
17	1.240	1.210	1.020	1.340	1.670
18	1.240	1.530	1.170	1.420	1.800
19	1.210	1.560	1.190	1.710	1.790
20	1.120	1.590	1.090	1.720	1.840
21	1.050	1.390	1.070	1.650	1.680
22	1.220	1.300	1.120	1.560	1.640
23	1.160	1.580	1.090	1.690	1.830
24	1.180	1.580	1.290	1.770	2.060
25	1.170	1.730	1.300	1.550	1.800
26	1.300	1.470	1.390	1.810	1.650
27	1.250	1.610	1.450	1.770	1.770
28	1.130	1.630	1.440	1.810	1.770
29	1.240	1.810	1.190	1.690	1.630
30	1.440	1.770	1.510	1.780	1.700
31	1.240	1.710	1.600	1.770	1.630
32	1.330	1.380	1.630	1.870	1.860
33	1.310	1.440	1.410	1.690	1.710
34	1.250	1.570	1.590	1.710	1.640
35	1.260	1.520	1.450	1.800	1.790
36	1.180	1.420	1.540	1.630	1.740
37	1.190	1.400	1.640	1.740	1.520
38	1.110	1.610	1.690	2.040	1.710
39	1.310	1.560	1.380	1.960	1.960
40	1.210	1.550	1.580	1.870	1.880
41	1.200	1.360	1.480	1.840	1.600
42	1.200	1.620	1.570	1.790	1.850
43	1.270	1.730	1.520	1.680	1.920
44	1.300	1.830	1.670	2.070	1.820
45	1.280	1.680	1.310	1.960	1.900
46	1.220	1.760	1.380	1.850	2.000
47	1.290	1.600	1.380	1.950	1.770
48	1.220	1.630	1.470	1.880	1.700
49	1.320	1.490	1.520	1.930	1.900
50	1.290	1.350	1.640	1.920	1.680
51	1.430	1.440	1.870	1.900	1.960
52	1.400	1.470	1.810	1.950	1.900
53	1.290	1.670	1.590	1.790	1.700
54	1.350	1.630	1.430	1.880	1.900
55	1.270	1.710	1.330	1.960	1.900
56	1.310	1.770	1.510	2.070	1.720
57	1.250	1.610	1.440	1.950	1.710
58	1.280	1.590	1.540	1.860	1.850
59	1.320	1.550	1.750	1.880	1.730
60	1.340	1.790	1.510	1.940	1.780
61	1.490	1.540	1.460	1.740	1.630
62	1.290	1.700	1.580	2.030	1.730
63	1.430	1.580	1.650	1.850	1.750
64	1.330	1.560	1.570	1.720	1.900

SUBJECT 180 VARIABLE ACCURACY

WORK SESSION	RUN BASELINE	EXPOSURE	24 POST	48 POST	72 POST
1	1.000	0.990	1.000	0.990	1.000
2	1.000	1.000	1.000	1.000	1.000
3	1.000	1.000	1.000	1.000	1.000
4	0.990	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	0.990	1.000
9	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	0.990	0.990	1.000
12	0.990	1.000	0.990	1.000	1.000
13	0.990	0.950	1.000	1.000	1.000
14	1.000	0.990	1.000	1.000	1.000
15	0.980	0.990	1.000	1.000	1.000
16	0.980	0.990	1.000	1.000	1.000
17	1.000	0.990	1.000	0.970	0.990
18	1.000	1.000	1.000	0.990	1.000
19	0.990	1.000	1.000	1.000	0.990
20	0.980	1.000	1.000	1.000	1.000
21	0.980	0.980	1.000	1.000	1.000
22	0.990	0.990	1.000	1.000	1.000
23	0.990	0.990	0.990	1.000	1.000
24	1.000	0.960	1.000	1.000	1.000
25	1.000	1.000	1.000	0.990	0.990
26	1.000	0.960	1.000	1.000	1.000
27	1.000	0.990	1.000	1.000	0.990
28	0.990	0.990	1.000	0.990	1.000
29	0.980	0.990	1.000	0.990	1.000
30	1.000	1.000	1.000	1.000	1.000
31	1.000	0.990	1.000	1.000	1.000
32	1.000	0.990	1.000	0.990	1.000
33	0.990	0.990	0.990	1.000	1.000
34	1.000	0.990	0.990	0.990	1.000
35	1.000	1.000	1.000	1.000	1.000
36	1.000	0.990	1.000	1.000	1.000
37	1.000	1.000	1.000	1.000	1.000
38	1.000	1.000	1.000	1.000	1.000
39	0.990	0.990	1.000	0.990	1.000
40	1.000	0.990	1.000	0.990	1.000
41	1.000	1.000	1.000	1.000	1.000
42	1.000	0.990	1.000	1.000	0.990
43	0.990	1.000	0.990	1.000	0.910
44	1.000	0.980	1.000	1.000	0.990
45	1.000	0.990	1.000	0.990	1.000
46	1.000	1.000	1.000	0.980	1.000
47	1.000	1.000	1.000	1.000	0.990
48	1.000	0.990	0.990	1.000	1.000
49	0.970	1.000	1.000	1.000	1.000
50	1.000	0.980	1.000	0.990	1.000
51	0.990	1.000	1.000	1.000	1.000
52	0.990	0.990	1.000	0.980	1.000
53	1.000	0.990	0.990	1.000	1.000
54	1.000	0.980	1.000	1.000	1.000
55	1.000	1.000	1.000	0.990	0.990
56	1.000	1.000	1.000	1.000	0.990
57	1.000	1.000	0.990	0.990	1.000
58	0.990	0.990	1.000	1.000	1.000
59	1.000	0.980	1.000	1.000	1.000
60	0.990	0.990	0.990	1.000	1.000
61	1.000	1.000	0.990	0.980	1.000
62	1.000	1.000	1.000	0.990	1.000
63	1.000	0.990	1.000	0.990	1.000
64	1.000	1.000	1.000	1.000	1.000

SUBJECT 180 VARIABLE REACT TIME

WORK SESSION	RUN				
	BASELINE	EXPOSURE	24 POST	48 POST	72 POST
1	0.860	0.780	0.740	1.130	0.980
2	0.970	0.750	0.700	0.920	1.030
3	1.160	0.770	0.720	0.970	1.040
4	1.030	0.770	0.730	1.050	1.080
5	0.840	0.870	0.780	1.100	1.100
6	0.940	0.940	0.730	1.090	1.100
7	0.980	1.050	0.720	1.300	1.130
8	1.110	1.200	0.800	1.330	1.150
9	1.090	0.870	0.830	1.220	1.160
10	1.210	0.950	0.780	1.290	1.120
11	1.200	0.930	0.710	1.240	1.110
12	1.220	1.060	0.660	1.130	1.200
13	1.210	1.210	0.750	1.170	1.170
14	1.170	1.240	0.670	1.170	1.170
15	1.110	1.260	0.660	1.210	1.130
16	1.020	1.250	0.720	1.310	1.210
17	1.030	1.130	0.830	1.340	1.210
18	1.160	1.170	0.730	1.180	1.250
19	1.150	1.320	0.720	1.050	1.210
20	1.110	1.820	0.740	1.080	1.090
21	1.030	1.130	0.910	1.100	1.080
22	1.030	1.200	0.760	1.150	1.090
23	1.040	1.250	0.700	1.230	1.090
24	1.000	1.090	0.730	1.310	1.140
25	1.080	1.220	0.860	1.370	1.170
26	1.070	1.050	0.780	1.240	1.170
27	1.170	1.380	0.740	1.300	1.070
28	1.130	1.410	0.760	1.460	0.980
29	1.040	1.180	1.190	1.420	1.020
30	0.960	1.270	0.940	1.350	1.030
31	0.950	1.300	0.910	1.290	1.030
32	1.030	1.140	0.840	1.330	1.030
33	1.120	1.110	1.140	1.270	1.040
34	1.010	1.000	0.900	1.250	1.070
35	1.080	1.030	0.780	1.160	1.130
36	1.040	1.100	0.850	1.180	1.200
37	1.220	1.260	0.980	1.290	1.120
38	1.200	1.350	0.950	1.290	1.220
39	1.270	1.470	0.990	1.500	1.220
40	1.090	1.380	0.980	1.380	1.340
41	1.160	1.260	1.260	1.300	1.220
42	1.190	1.210	1.050	1.220	1.300
43	1.110	1.340	0.990	1.310	1.450
44	1.120	1.320	0.920	1.280	1.060
45	1.140	1.240	1.040	1.430	1.080
46	1.030	1.060	0.980	1.240	1.040
47	1.200	1.230	0.880	1.200	1.040
48	1.180	1.200	0.950	1.260	1.040
49	1.110	1.090	1.250	1.320	1.090
50	1.040	0.970	1.150	1.440	1.040
51	1.050	1.170	1.100	1.330	1.040
52	1.080	1.240	1.140	1.340	1.190
53	0.930	1.150	1.220	1.220	1.250
54	1.110	1.090	1.090	1.170	1.280
55	1.180	1.030	0.970	1.240	1.240
56	1.210	1.220	1.090	1.270	1.210
57	1.220	1.270	1.280	1.350	1.240
58	1.200	1.160	1.070	1.290	1.150
59	1.230	1.360	1.030	1.340	1.120
60	1.270	1.090	1.160	1.390	1.140
61	1.240	1.050	1.170	1.550	1.230
62	1.300	1.210	0.950	1.390	1.280
63	1.480	1.280	1.060	1.430	1.240
64	1.490	1.280	0.950	1.430	1.170

SUBJECT 184 VARIABLE ACCURACY

WORK SESSION	RUN BASELINE	EXPOSURE	24 POST	48 POST	72 POST
1	1 000	1.000	1.000	1.000	1.000
2	1.000	1.000	1.000	1.000	1.000
3	1.000	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	0.990	1.000
10	0.990	1.000	1.000	1.000	1.000
11	1.000	0.930	1.000	1.000	1.000
12	1.000	0.940	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1 000	1.000
15	1.000	1.000	1 000	1 000	1.000
16	1.000	1.000	1.000	1.000	1.000
17	1.000	1.000	0.980	1.000	1.000
18	1.000	0.990	1.000	1.000	1.000
19	1.000	1.000	1.000	1.000	1.000
20	1.000	1.000	1.000	1.000	1.000
21	1.000	0 990	1.000	1.000	1.000
22	1.000	0.990	1.000	1.000	1.000
23	1.000	1.000	1.000	1.000	1.000
24	1.000	1.000	1.000	1.000	1.000
25	1.000	1.000	1.000	1.000	1.000
26	1.000	1.000	1.000	1.000	1.000
27	1.000	1.000	0.990	1.000	0.990
28	0.990	1.000	1.000	1.000	1.000
29	0 990	1.000	1.000	1.000	1.000
30	1.000	1.000	0.990	1.000	1.000
31	1.000	1.000	1.000	1.000	1.000
32	1.000	0.990	1.000	1.000	1.000
33	1.000	1.000	1.000	0.990	1.000
34	1.000	1.000	1.000	0.990	1.000
35	1.000	0 990	1.000	0.990	1.000
36	1.000	1 000	1.000	1.000	0.990
37	1.000	1.000	1.000	1.000	0.990
38	1.000	0.990	1.000	1.000	1.000
39	1.000	1.000	1.000	1.000	1.000
40	1.000	1.000	0.990	1.000	1.000
41	1.000	0.990	0.990	1.000	1.000
42	1.000	1.000	1.000	1.000	1.000
43	1.000	1.000	1.000	1.000	1.000
44	1.000	1.000	1.000	1.000	1 000
45	1.000	1.000	1.000	1.000	1.000
46	1.000	0.990	1 000	0.990	1.000
47	1.000	1.000	0.990	1.000	1.000
48	1.000	1.000	1.000	1.000	1.000
49	1.000	0.990	1.000	1.000	1.000
50	0.990	1.000	1.000	1.000	1.000
51	1.000	1.000	1.000	1.000	1.000
52	0.990	1.000	1.000	1.000	1.000
53	1.000	1.000	1.000	0.990	1.000
54	1.000	1.000	1.000	0.990	1.000
55	1.000	1.000	1.000	1.000	1.000
56	1.000	1.000	1.000	1.000	1.000
57	1.000	0.990	1.000	1.000	1.000
58	1.000	1.000	1.000	1.000	0.990
59	0.990	1.000	1.000	1.000	1.000
60	1.000	1.000	1.000	1.000	1.000
61	1.000	0.980	1.000	1.000	1.000
62	1.000	1.000	1.000	1.000	1.000
63	1.000	1.000	1.000	1.000	1.000
64	0.990	1.000	1.000	1.000	1.000

SUBJECT 184 VARIABLE REACT TIME

WORK SESSION	RUN BASELINE	EXPOSURE	24 POST	48 POST	72 POST
1	0.670	0.660	0.780	0.920	0.890
2	0.660	0.690	0.740	0.870	1.030
3	0.730	0.730	0.730	0.960	1.000
4	0.710	0.730	0.760	0.910	0.860
5	0.730	0.700	0.650	1.100	1.150
6	0.710	0.700	0.770	1.080	1.230
7	0.760	0.720	0.800	1.130	1.280
8	0.790	0.730	0.820	1.110	1.440
9	0.780	0.690	0.770	0.890	1.330
10	0.810	0.640	0.870	1.000	1.170
11	0.840	0.630	0.870	1.080	1.360
12	0.890	0.980	0.840	1.020	1.270
13	0.860	0.930	0.980	1.010	1 320
14	0.840	1.050	0.930	1.000	1.190
15	0.800	0.990	0.910	1.000	1.290
16	0.860	1.090	0.960	1.080	1.140
17	0.880	1.040	0.900	1.100	1.330
18	0.930	1.300	1.010	1.110	1.440
19	0.860	1.230	0.910	1.020	1.570
20	0.920	1.210	0.980	1.010	1.570
21	0.960	0.960	1.000	1.270	1.530
22	0.980	0.920	0.920	1.220	1.480
23	1.020	0.870	1.050	1.290	1.460
24	0.890	0.910	1.150	1.170	1.340
25	0.970	1.060	1.030	1.240	1.600
26	0.940	1.010	1.150	1.360	1.820
27	0.930	0.780	1.020	1.220	1.210
28	0.980	0.890	0.990	1.140	1.090
29	0.830	0.890	0.970	1.500	1.320
30	0.890	0.990	1.030	1.390	1.430
31	0.860	1.110	1.060	1.360	1.060
32	0.950	1.200	0.950	1.720	1.370
33	0.790	1.150	1.160	1.410	1.500
34	0.840	1.230	1.090	1.190	1.710
35	0.840	1.290	1.090	1.090	1.750
36	1.070	1.310	0.980	1.150	1.410
37	0.880	1.390	1.060	1.270	1.270
38	1.010	1.320	1.120	1.180	1.240
39	1.020	1.240	0.980	1.280	1.430
40	1.130	1.290	0.900	1.270	1.230
41	1.040	1.090	0.890	1.220	1.300
42	0.870	1.170	0.930	1.340	1.340
43	0.980	1.290	0.870	1.360	1.510
44	1.260	1.250	1.020	1.350	1.440
45	1.020	1.160	1.020	1.370	1.340
46	1.090	1.120	1.100	1.360	1.340
47	1.300	1.030	1.030	1.450	1.370
48	1.080	1.210	1.020	1.420	1.440
49	1.210	1.040	1.180	1.620	1.270
50	0.950	1.180	1.240	1.700	1.230
51	0.950	1.220	1.130	1.410	1.150
52	0.820	1.160	1.090	1.300	1.310
53	0.970	1.220	1.140	1.500	1.290
54	0.980	1.320	1.080	1.430	1.340
55	0.990	1.400	1.050	1.240	1.270
56	1.170	1.420	1.030	1.320	1.260
57	1.070	1.310	1.110	1.310	1.370
58	1.240	1.370	1.190	1.280	1.910
59	1.100	1.530	1.070	1.300	1.420
60	0.800	1.450	0.940	1.320	1.500
61	0.960	1.260	1.200	1.640	1.340
62	1.050	1.410	1.210	1.360	1.590
63	1.230	1.490	1.400	1.550	1.620
64	1.110	1.310	1.140	1.580	1.550

SUBJECT 154 VARIABLE ACCURACY

WORK SESSION	RUN BASELINE	EXPOSURE	24 POST	48 POST	72 POST
1	1.000	1.000	0.990	1.000	0.990
2	0.990	1.000	1.000	1.000	1.000
3	1.000	1.000	1.000	0.990	1.000
4	0.990	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000
7	0.990	1.000	1.000	1.000	1.000
8	0.990	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000
10	1.000	0.990	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	0.980
13	1.000	0.990	1.000	1.000	1.000
14	0.990	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000	1.000
16	1.000	0.990	1.000	0.990	1.000
17	1.000	1.000	1.000	0.980	1.000
18	1.000	1.000	1.000	1.000	1.000
19	1.000	0.990	1.000	1.000	1.000
20	1.000	1.000	1.000	1.000	1.000
21	1.000	1.000	1.000	1.000	0.990
22	1.000	1.000	1.000	1.000	1.000
23	1.000	1.000	1.000	1.000	1.000
24	1.000	1.000	1.000	1.000	1.000
25	1.000	0.990	0.990	1.000	1.000
26	1.000	1.000	1.000	1.000	1.000
27	0.980	1.000	1.000	1.000	1.000
28	1.000	1.000	1.000	0.990	1.000
29	1.000	0.990	1.000	1.000	1.000
30	1.000	1.000	1.000	1.000	1.000
31	0.990	1.000	0.990	1.000	1.000
32	0.990	1.000	1.000	1.000	1.000
33	1.000	1.000	1.000	1.000	1.000
34	0.910	1.000	1.000	1.000	0.990
35	0.890	0.990	1.000	0.990	1.000
36	1.000	1.000	1.000	1.000	0.990
37	1.000	0.990	1.000	1.000	1.000
38	1.000	1.000	1.000	0.990	0.990
39	1.000	1.000	1.000	1.000	0.990
40	1.000	1.000	1.000	1.000	1.000
41	1.000	0.970	1.000	1.000	0.990
42	1.000	1.000	1.000	1.000	1.000
43	1.000	1.000	1.000	1.000	1.000
44	1.000	0.990	1.000	1.000	1.000
45	1.000	0.980	1.000	1.000	0.990
46	1.000	0.990	1.000	0.990	1.000
47	1.000	1.000	1.000	0.990	1.000
48	1.000	1.000	1.000	1.000	1.000
49	1.000	1.000	1.000	0.990	1.000
50	1.000	0.990	1.000	1.000	0.990
51	0.990	1.000	0.990	1.000	1.000
52	1.000	0.990	1.000	1.000	1.000
53	1.000	0.990	1.000	0.990	1.000
54	1.000	0.990	1.000	1.000	1.000
55	1.000	1.000	0.990	1.000	1.000
56	1.000	0.970	1.000	1.000	1.000
57	1.000	0.990	1.000	1.000	1.000
58	1.000	1.000	1.000	0.980	1.000
59	1.000	1.000	1.000	1.000	0.990
60	1.000	1.000	1.000	1.000	1.000
61	1.000	0.980	1.000	0.990	1.000
62	1.000	0.990	1.000	1.000	1.000
63	1.000	1.000	0.990	1.000	0.980
64	0.990	1.000	0.990	0.990	1.000

SUBJECT 154 VARIABLE REACT TIME

WORK SESSION	RUN BASELINE	EXPOSURE	24 POST	48 POST	72 POST
1	0.710	0.630	0.730	0.960	0.700
2	0.660	0.630	0.760	0.990	0.800
3	0.650	0.670	0.770	0.980	0.890
4	0.580	0.740	0.830	0.930	0.880
5	0.610	0.740	0.800	0.980	0.890
6	0.660	0.740	0.830	0.980	0.980
7	0.620	0.760	0.880	1.030	1.030
8	0.590	0.740	0.870	1.040	1.050
9	0.660	0.680	0.900	1.130	1.030
10	0.650	0.690	0.960	1.050	1.090
11	0.680	0.740	1.050	1.110	1.180
12	0.700	0.770	0.980	1.180	0.930
13	0.770	0.760	0.920	1.220	1.030
14	0.690	0.860	0.950	1.280	1.030
15	0.690	0.880	1.050	1.360	0.980
16	0.690	0.780	1.010	1.270	1.030
17	0.650	0.760	0.980	1.080	1.080
18	0.710	0.730	0.990	1.090	1.080
19	0.760	0.840	1.080	1.080	1.120
20	0.760	0.910	1.050	1.100	1.160
21	0.830	0.980	1.110	1.140	1.020
22	0.840	0.820	1.180	1.140	1.160
23	0.810	0.990	1.110	1.150	1.220
24	0.840	1.000	1.240	1.200	1.180
25	0.850	1.180	1.040	1.190	1.210
26	0.900	1.110	1.160	1.220	1.230
27	0.810	1.070	1.280	1.370	1.140
28	0.830	1.080	1.220	1.240	1.000
29	0.880	1.070	1.220	1.210	1.330
30	0.850	1.060	1.200	1.170	1.300
31	0.910	1.090	1.060	1.220	1.320
32	0.690	1.050	1.170	1.250	1.330
33	0.760	1.130	1.110	1.270	1.310
34	0.840	1.030	1.150	1.380	1.330
35	0.890	0.980	1.130	1.170	1.360
36	0.790	1.070	1.110	1.160	1.200
37	0.730	1.080	1.080	1.010	1.260
38	0.810	1.250	1.110	1.030	1.190
39	0.840	1.290	1.120	1.150	1.280
40	0.860	1.110	1.180	1.070	1.200
41	0.980	1.080	1.230	1.000	1.040
42	1.010	1.290	1.180	1.180	1.050
43	1.030	1.200	1.220	1.210	1.120
44	1.030	1.160	1.160	1.130	1.060
45	1.000	1.050	1.230	1.260	1.100
46	0.980	1.150	1.230	1.330	1.010
47	0.950	1.130	1.170	1.190	1.050
48	0.980	1.160	1.200	1.220	1.080
49	1.030	1.120	1.340	1.170	1.160
50	1.010	1.210	1.390	1.170	1.020
51	0.910	1.290	1.270	1.180	1.100
52	0.980	1.390	1.310	1.200	1.200
53	0.990	1.250	1.400	1.240	1.030
54	0.910	1.340	1.420	1.130	1.070
55	0.990	1.380	1.160	1.200	1.000
56	0.930	1.250	1.250	1.150	1.160
57	0.980	1.190	1.050	1.180	1.010
58	1.040	1.140	1.120	1.040	1.170
59	0.990	1.150	1.210	1.130	1.250
60	0.960	1.270	1.200	1.070	1.210
61	1.040	1.230	1.200	1.130	1.230
62	1.100	1.160	1.110	1.140	1.250
63	1.050	1.100	1.150	1.160	1.120
64	0.990	1.050	1.220	1.190	1.220

SUBJECT 160 VARIABLE ACCURACY

WORK SESSION	RUN: BASELINE	EXPOSURE	24 POST	48 POST	72 POST
1	1.000	1.000	1.000	1.000	1.000
2	1.000	1.000	1.000	1.000	1.000
3	1.000	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	0.990	1.000
7	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000
13	1.000	1.000	0.990	1.000	1.000
14	0.990	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000	1.000
16	1.000	1.000	1.000	1.000	1.000
17	1.000	1.000	1.000	1.000	1.000
18	1.000	1.000	1.000	1.000	1.000
19	0.990	1.000	*********	1.000	1.000
20	0.990	1.000	*********	1.000	1.000
21	1.000	1.000	1.000	1.000	1.000
22	1.000	1.000	1.000	1.000	1.000
23	1.000	0.990	1.000	1.000	1.000
24	1.000	1.000	1.000	1.000	1.000
25	0.990	0.990	1.000	1.000	1.000
26	1.000	1.000	1.000	1.000	1.000
27	1.000	1.000	1.000	1.000	1.000
28	1.000	1.000	1.000	1.000	1.000
29	1.000	1.000	1.000	1.000	1.000
30	1.000	1.000	1.000	1.000	1.000
31	1.000	1.000	1.000	1.000	1.000
32	1.000	0.990	1.000	1.000	1.000
33	1.000	1.000	0.990	1.000	1.000
34	1.000	1.000	1.000	1.000	1.000
35	1.000	1.000	1.000	1.000	1.000
36	1.000	1.000	0.990	1.000	1.000
37	1.000	1.000	1.000	1.000	1.000
38	1.000	1.000	1.000	1.000	1.000
39	1.000	1.000	1.000	1.000	1.000
40	1.000	1.000	1.000	1.000	1.000
41	1.000	1.000	1.000	0.990	1.000
42	1.000	1.000	1.000	1.000	1.000
43	1.000	1.000	0.990	1.000	1.000
44	1.000	1.000	0.990	1.000	1.000
45	1.000	1.000	1.000	0.990	1.000
46	1.000	1.000	0.990	1.000	1.000
47	1.000	1.000	1.000	1.000	1.000
48	1.000	1.000	1.000	1.000	1.000
49	0.990	0.980	1.000	1.000	1.000
50	1.000	0.990	0.990	1.000	1.000
51	1.000	1.000	1.000	1.000	1.000
52	1.000	0.990	1.000	1.000	1.000
53	1.000	1.000	1.000	1.000	0.990
54	1.000	1.000	1.000	1.000	1.000
55	1.000	1.000	0.990	1.000	1.000
56	0.980	1.000	0.990	0.980	1.000
57	1.000	1.000	0.990	1.000	1.000
58	1.000	1.000	1.000	1.000	1.000
59	1.000	1.000	1.000	1.000	1.000
60	0.400	1.000	0.990	1.000	1.000
61	1.000	1.000	1.000	1.000	1.000
62	1.000	0.990	1.000	1.000	1.000
63	0.990	1.000	0.990	1.000	1.000
64	0.990	1.000	0.990	1.000	1.000

SUBJECT 160 VARIABLE REACT TIME

WORK SESSION	RUN BASELINE	EXPOSURE	24 POST	48 POST	72 POST
1	0.580	0.490	0.550	0.740	0.660
2	0.520	0.480	0.550	0.750	0.690
3	0.530	0.490	0.570	0.770	0.690
4	0.510	0.490	0.570	0.830	0.720
5	0.610	0.500	0.600	0.920	0.820
6	0.570	0.490	0.610	0.850	0.720
7	0.580	0.510	0.600	0.900	0.730
8	0.650	0.510	0.590	0.800	0.770
9	0.710	0.530	0.600	0.920	0.790
10	0.710	0.480	0.620	0.810	0.720
11	0.740	0.520	0.630	0.790	0.710
12	0.740	0.540	0.660	0.790	0.710
13	0.800	0.590	0.570	0.890	0.770
14	0.760	0.560	0.580	0.840	0.700
15	0.640	0.560	0.590	0.820	0.670
16	0.730	0.570	0.580	0.740	0.680
17	0.740	0.740	0.600	0.800	0.760
18	0.680	0.750	0.600	0.800	0.720
19	0.680	0.810	********	0.820	0.710
20	0.690	0.960	********	0.790	0.700
21	0.690	0.950	0.630	0.890	0.730
22	0.600	0.980	0.600	0.840	0.740
23	0.660	1.000	0.570	0.800	0.720
24	0.610	0.950	0.570	0.730	0.800
25	0.660	0.930	0.620	0.860	0.710
26	0.580	1.150	0.560	0.840	0.720
27	0.560	1.110	0.580	0.770	0.760
28	0.560	1.130	0.570	0.770	0.800
29	0.610	1.050	0.650	0.900	0.740
30	0.610	1.070	0.610	0.850	0.780
31	0.600	1.170	0.580	0.810	0.730
32	0.580	0.810	0.610	0.880	0.780
33	0.760	0.830	0.590	0.940	0.830
34	0.640	0.840	0.570	0.870	0.780
35	0.660	0.830	0.620	0.880	0.790
36	0.710	0.890	0.540	0.850	0.740
37	0.790	0.990	0.640	0.980	0.780
38	0.700	0.920	0.580	0.920	0.770
39	0.660	0.830	0.580	0.920	0.740
40	0.710	0.920	0.620	0.810	0.760
41	0.870	0.920	0.680	0.990	0.850
42	0.740	0.920	0.610	0.870	0.740
43	0.720	0.900	0.580	0.950	0.760
44	0.670	0.890	0.580	0.890	0.780
45	0.940	0.920	0.660	0.900	0.870
46	0.700	0.920	0.640	0.780	0.790
47	0.680	0.910	0.610	0.800	0.770
48	0.710	0.910	0.650	0.810	0.810
49	0.710	0.850	0.690	0.940	0.860
50	0.670	0.850	0.600	0.830	0.800
51	0.710	0.940	0.630	0.890	0.780
52	0.760	0.780	0.660	0.890	0.810
53	0.670	0.810	0.690	0.920	0.760
54	0.640	0.780	0.680	0.830	0.780
55	0.660	0.760	0.790	0.860	0.830
56	0.630	0.680	0.620	0.920	0.830
57	0.630	0.760	0.730	0.940	0.860
58	0.610	0.730	0.620	0.850	0.800
59	0.710	0.720	0.680	0.850	0.740
60	0.960	0.730	0.720	0.910	0.780
61	0.570	0.710	0.780	0.940	0.980
62	0.520	0.720	0.740	0.870	0.850
63	0.540	0.670	0.690	0.890	0.800
64	0.520	0.680	0.800	0.870	0.870

SUBJECT L64 VARIABLE ACCURACY

WORK SESSION	BASELINE	EXPOSURE	24 POST	48 POST	72 POST
			RUN		
1	1.000	0.990	0.990	1.000	1.000
2	1.000	0.990	0.980	1.000	0.980
3	0.990	1.000	1.000	0.990	0.990
4	1.000	0.990	1.000	1.000	1.000
5	0.990	1.000	0.990	1.000	0.990
6	0.990	1.000	1.000	1.000	1.000
7	0.980	1.000	0.990	0.980	1.000
8	1.000	1.000	0.990	0.990	1.000
9	1.000	0.980	1.000	1.000	1.000
10	1.000	1.000	1.000	0.980	1.000
11	1.000	0.990	1.000	0.990	1.000
12	1.000	0.990	1.000	1.000	0.990
13	0.990	1.000	0.980	1.000	0.990
14	1.000	1.000	1.000	1.000	1.000
15	0.990	1.000	1.000	1.000	0.990
16	1.000	0.960	0.980	0.990	1.000
17	1.000	0.930	1.000	0.990	0.990
18	1.000	0.980	1.000	0.990	1.000
19	1.000	0.990	1.000	1.000	1.000
20	0.990	0.960	1.000	0.980	1.000
21	1.000	0.980	1.000	1.000	1.000
22	0.990	0.980	0.990	1.000	1.000
23	0.990	0.990	1.000	1.000	1.000
24	1.000	0.880	0.980	1.000	1.000
25	1.000	0.990	1.000	0.990	0.990
26	1.000	0.980	1.000	1.000	1.000
27	1.000	0.980	1.000	0.990	1.000
28	0.990	1.000	1.000	1.000	0.990
29	0.990	0.980	0.980	0.980	0.990
30	1.000	0.990	1.000	1.000	1.000
31	1.000	0.990	1.000	1.000	1.000
32	0.990	0.990	1.000	0.990	1.000
33	1.000	0.980	0.990	0.980	1.000
34	0.970	0.960	0.990	0.990	0.990
35	0.990	0.950	1.000	0.990	1.000
36	1.000	0.950	0.990	1.000	1.000
37	0.990	0.950	0.990	0.970	1.000
38	1.000	0.960	0.970	1.000	0.980
39	1.000	0.980	1.000	0.990	1.000
40	0.990	0.980	1.000	0.990	0.980
41	0.990	0.970	1.000	0.980	0.990
42	0.990	0.940	1.000	0.980	0.990
43	1.000	0.980	0.990	1.000	0.990
44	1.000	0.980	1.000	1.000	0.990
45	1.000	0.970	1.000	1.000	0.990
46	1.000	1.000	1.000	0.970	1.000
47	1.000	0.960	0.980	0.980	1.000
48	1.000	0.970	0.990	0.950	1.000
49	0.980	0.970	0.990	1.000	1.000
50	1.000	0.980	1.000	1.000	0.990
51	1.000	0.970	1.000	1.000	0.990
52	0.980	0.980	0.970	0.970	1.000
53	1.000	0.960	1.000	0.980	0.990
54	1.000	1.000	0.990	0.990	1.000
55	1.000	1.000	0.990	0.990	1.000
56	1.000	0.970	0.990	0.980	1.000
57	0.980	0.960	1.000	0.980	0.980
58	1.000	0.980	1.000	0.990	1.000
59	0.990	0.950	1.000	0.990	0.980
60	1.000	1.000	0.980	0.990	0.990
61	0.990	1.000	0.990	0.970	1.000
62	1.000	0.980	1.000	0.990	0.980
63	1.000	0.970	1.000	0.960	1.000
64	1.000	0.980	1.000	1.000	0.990

SUBJECT L64 VARIABLE REACT TIME

WORK SESSION	BASELINE	EXPOSURE	24 POST	48 POST	72 POST
			RUN		
1	1.150	1.170	1.230	1.250	1.170
2	1.120	1.340	1.160	1.300	1.090
3	1.110	1.250	0.980	1.190	1.140
4	1.120	1.110	1.080	1.250	1.210
5	1.190	1.050	0.870	1.250	1.190
6	1.030	1.020	0.880	1.230	1.110
7	1.210	0.990	0.990	1.200	1.110
8	1.090	0.960	1.070	1.170	1.080
9	1.010	1.130	0.900	1.090	1.090
10	0.910	0.950	0.980	1.110	1.040
11	0.900	0.870	1.000	1.080	1.060
12	0.970	0.830	1.020	1.090	1.070
13	1.160	0.840	0.940	1.050	1.130
14	0.990	0.880	1.040	1.090	0.990
15	1.010	1.200	1.020	1.070	0.980
16	1.090	1.500	0.910	1.080	0.980
17	1.060	1.540	0.930	0.990	0.990
18	0.950	1.540	1.040	1.070	0.990
19	0.910	1.880	0.970	1.080	0.970
20	1.000	1.820	1.010	1.150	0.970
21	1.030	1.640	1.050	1.070	1.020
22	0.870	1.710	1.060	1.040	0.920
23	0.870	1.790	1.210	1.060	0.950
24	0.940	1.270	1.070	1.090	1.160
25	1.080	1.360	1.020	1.230	1.100
26	1.040	1.610	0.950	1.200	1.090
27	1.040	1.520	1.060	1.080	1.050
28	1.130	1.470	1.080	1.140	1.360
29	1.120	1.360	0.980	1.070	1.020
30	1.020	1.280	1.080	1.160	1.040
31	1.140	1.270	1.070	1.100	0.990
32	1.070	1.350	1.010	1.200	1.020
33	1.180	1.410	1.090	1.300	1.320
34	1.250	1.530	1.110	1.200	1.290
35	1.180	1.450	1.120	1.150	1.130
36	1.160	1.710	1.180	1.140	1.090
37	1.330	1.730	1.170	1.340	1.220
38	1.170	1.380	1.070	1.300	1.200
39	1.120	1.460	0.970	1.350	1.110
40	1.160	1.590	1.000	1.270	1.170
41	1.280	1.280	1.090	1.350	1.190
42	1.160	1.190	1.140	1.130	1.140
43	1.130	1.490	1.150	1.200	1.130
44	1.180	1.400	1.140	1.220	1.240
45	1.250	1.240	1.090	1.210	1.110
46	1.210	1.170	1.180	1.230	1.010
47	1.200	1.110	1.170	1.240	1.020
48	1.120	0.980	1.250	1.200	1.070
49	1.360	1.040	1.060	1.140	1.180
50	1.290	1.170	1.170	1.150	1.190
51	1.190	1.290	1.290	1.380	1.280
52	1.370	1.390	1.140	1.420	1.210
53	1.320	1.160	1.090	1.410	1.250
54	1.200	1.460	1.150	1.340	1.090
55	1.280	1.640	1.250	1.330	1.120
56	1.320	1.590	1.190	1.320	1.160
57	1.300	1.370	0.980	1.270	1.200
58	1.170	1.430	1.060	1.360	1.140
59	1.220	1.180	1.120	1.370	1.210
60	1.180	1.480	1.160	1.380	1.210
61	1.280	1.410	0.920	1.380	1.260
62	1.090	1.450	1.070	1.380	1.090
63	1.060	1.410	1.090	1.290	1.100
64	1.230	1.370	1.010	1.250	1.080

SUBJECT 174 VARIABLE ACCURACY

WORK SESSION	BASELINE	EXPOSURE	RUN 24 POST	48 POST	72 POST
1	1.000	1.000	1.000	0.970	1.000
2	1.000	1.000	1.000	0.980	1.000
3	1.000	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	0.990	1.000
7	0.990	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	0.990	1.000
11	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000	1.000
16	0.990	1.000	1.000	1.000	1.000
17	1.000	0.990	0.990	0.990	1.000
18	1.000	1.000	1.000	1.000	1.000
19	1.000	1.000	1.000	1.000	1.000
20	1.000	1.000	1.000	1.000	1.000
21	1.000	1.000	1.000	1.000	1.000
22	1.000	1.000	1.000	1.000	1.000
23	0.990	1.000	1.000	1.000	1.000
24	1.000	0.990	1.000	1.000	1.000
25	1.000	1.000	1.000	1.000	1.000
26	1.000	0.990	1.000	1.000	1.000
27	0.990	1.000	1.000	1.000	1.000
28	1.000	1.000	1.000	1.000	1.000
29	1.000	1.000	1.000	0.990	1.000
30	0.960	0.990	1.000	1.000	1.000
31	1.000	1.000	1.000	1.000	1.000
32	1.000	1.000	1.000	1.000	1.000
33	1.000	1.000	1.000	1.000	1.000
34	1.000	1.000	1.000	0.990	1.000
35	1.000	0.990	1.000	1.000	1.000
36	1.000	1.000	1.000	1.000	1.000
37	0.990	1.000	0.990	1.000	0.990
38	1.000	1.000	1.000	1.000	1.000
39	1.000	1.000	1.000	1.000	1.000
40	0.980	0.990	1.000	1.000	1.000
41	1.000	0.990	0.990	1.000	1.000
42	1.000	1.000	0.990	0.990	1.000
43	1.000	1.000	1.000	1.000	1.000
44	1.000	1.000	1.000	1.000	1.000
45	0.990	1.000	1.000	1.000	1.000
46	1.000	0.990	1.000	1.000	1.000
47	1.000	1.000	1.000	0.990	1.000
48	1.000	0.990	1.000	1.000	1.000
49	1.000	0.990	1.000	1.000	1.000
50	1.000	1.000	0.990	1.000	1.000
51	1.000	1.000	1.000	1.000	1.000
52	0.990	1.000	0.990	1.000	1.000
53	1.000	1.000	1.000	1.000	1.000
54	1.000	1.000	1.000	0.990	1.000
55	1.000	0.980	1.000	0.980	1.000
56	1.000	1.000	1.000	1.000	0.990
57	1.000	1.000	1.000	1.000	1.000
58	1.000	1.000	0.990	1.000	1.000
59	1.000	1.000	1.000	1.000	1.000
60	1.000	1.000	1.000	1.000	1.000
61	0.990	1.000	1.000	1.000	1.000
62	1.000	1.000	1.000	1.000	1.000
63	1.000	1.000	1.000	1.000	1.000
64	1.000	1.000	1.000	1.000	1.000

SUBJECT 174 VARIABLE REACT TIME

WORK SESSION	RUN				
	BASELINE	EXPOSURE	24 POST	48 POST	72 POST
1	0.620	0.560	0.520	0.940	0.630
2	0.630	0.550	0.610	0.810	0.640
3	0.630	0.640	0.650	0.720	0.630
4	0.590	0 600	0.570	0.830	0.660
5	0.590	0.540	0.650	0.910	0.710
6	0.600	0.510	0.610	0.800	0.690
7	0.590	0.490	0.600	0.790	0.680
8	0.580	0.510	0.650	0.790	0 700
9	0.610	0.550	0.620	0.850	0.720
10	0.600	0.590	0.590	0.820	0.650
11	0.670	0.630	0.590	0.860	0.690
12	0.700	0.700	0.610	0.940	0.690
13	0.670	0.740	0.780	0.940	0.720
14	0.720	0.750	0.650	0.890	0.700
15	0.620	0.770	0.670	1.010	0.640
16	0.650	0.700	0.740	0.940	0.690
17	0.660	0.610	0.780	1.030	0.720
18	0.680	0.650	0.630	0.960	0.680
19	0.660	0.710	0.650	0.940	0.690
20	0.670	0.700	0.680	1.040	0.670
21	0.660	0.770	0.860	1.030	0.700
22	0.650	0.860	0.690	1.000	0.660
23	0.650	0.860	0.730	1.010	0.750
24	0.650	0.870	0.680	1.050	0.760
25	0.690	0.770	0.960	1.060	0.700
26	0.630	0.830	0.730	1.060	0.690
27	0.680	1.030	0.720	1.040	0.690
28	0.670	0 770	0.770	1.150	0.750
29	0.690	1.280	0.880	1.140	0.710
30	0.640	0.970	0.840	1.110	0.780
31	0.660	0.960	0.880	1.070	0.750
32	0.680	0.880	0.850	1.100	0.680
33	0.680	0.980	1.000	1.090	0.770
34	0.730	1.110	0.740	1.080	0.700
35	0.770	0.910	0.840	1.020	0.710
36	0.670	0.860	0.870	1.070	0.790
37	0.700	1.030	1.050	1.060	0.770
38	0.680	0.930	0.860	0.960	0.740
39	0.650	1.070	0.800	0.960	0.710
40	0.660	1.170	0.860	1.070	0.760
41	0.700	1.060	0.970	1.180	0.800
42	0.660	0.900	0.730	1.170	0.770
43	0.680	0.960	0.730	0.990	0.780
44	0.820	1.000	0.770	1.050	0.740
45	0.700	0.930	0.900	1.120	0.780
46	0.750	0.880	0.840	1.010	0.730
47	0.800	0.930	0.700	1.130	0.740
48	0.710	0.970	0.770	1.000	0.770
49	0.760	0.800	0.940	1.210	0.790
50	0.680	0.850	0.840	1.070	0.720
51	0.740	0.800	0.700	1.140	0.730
52	0.920	0.770	0.710	1.080	0.710
53	0.750	0.900	0.810	1.130	0.830
54	0.700	0.990	0.670	1.210	0.730
55	0.760	0.770	0.690	1.040	0.760
56	0.700	0.720	0.710	1.090	0.690
57	0.770	0.780	0.810	1.110	0.830
58	0.810	0.770	0.740	1.120	0.760
59	0.810	0.780	0.720	1.060	0.710
60	0.830	0.770	0.770	0.990	0.750
61	0.800	0.840	0.810	1.110	0.860
62	0.800	0.900	0.770	1.050	0.750
63	0.690	0.930	0.780	1.130	0.750
64	0.730	0.950	0.790	1.130	0.700

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