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The purpose of this program is to develop the basis for cintinuing research of interest to the Air Force at the institution of the faculty member; to stiumlate continuing relations among faculty members and professional peers in the Air Force to enhance the research interests and capabilities of scientific and engineering educators; and to provide follow-on funding for research of particular promise that was started at an Air Force laboratory under the Summer Faculty Research Program.

During the summer of 1992 185 university faculty conducted research at Air Force laboratories for a period of 10 weeks. Each participant provided a report of their research, and these reports are consolidated into this annual report.

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UNITED STATES AIR FORCE

SUMMER RESEARCH PROGRAM -- 1992

HIGH SCHOOL APPRENTICESHIP PROGRAM (HSAP) REPORTS

VOLUME 12

ARMSTRONG LABORATORY

RESEARCH & DEVELOPMENT LABORATORIES
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Submitted to:

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
Bolling Air Force Base
Washington, D.C.
December 1992

PREFACE

This volume is part of a 16-volume set that summarizes the research accomplishments of faculty, graduate student, and high school participants in the 1992 Air Force Office of Scientific Research (AFOSR) Summer Research Program. The current volume, Volume 12 of 16, presents the final research reports of high school (HSAP) participants at Armstrong Laboratory.

Reports presented herein are arranged alphabetically by author and are numbered consecutively -- e.g., 1-1, 1-2, 1-3; 2-1, 2-2, 2-3.

Research reports in the 16-volume set are organized as follows:

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3	Summer Faculty Research Program Reports: Phillips Laboratory
4	Summer Faculty Research Program Reports: Rome Laboratory
5A	Summer Faculty Research Program Reports: Wright Laboratory (part one)
5B	Summer Faculty Research Program Reports: Wright Laboratory (part two)
6	Summer Faculty Research Program Reports: Arnold Engineering Development Center; Civil Engineering Laboratory; Frank J. Seiler Research Laboratory; Wilford Hall Medical Center
7	Graduate Student Research Program Reports: Armstrong Laboratory
8	Graduate Student Research Program Reports: Phillips Laboratory
9	Graduate Student Research Program Reports: Rome Laboratory
10	Graduate Student Research Program Reports: Wright Laboratory
11	Graduate Student Research Program Reports: Arnold Engineering Development Center; Civil Engineering Laboratory; Frank J. Seiler Research Laboratory; Wilford Hall Medical Center
12	High School Apprenticeship Program Reports: Armstrong Laboratory
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16	High School Apprenticeship Program Reports: Arnold Engineering Development Center; Civil Engineering Laboratory

1992 HIGH SCHOOL APPRENTICESHIP REPORTS

Armstrong Laboratory

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3	Dermal Penetration of Dibromomethane	Sara Berty
4	Pathology Laboratory Overview	Leah Elena Brown
5	Dietary Intake Patterns and Cardiac Evaluations of United States Air Force Pilots	Carmen Casares
6	Domestic Trends to the Year 2015	Deborah A. Case
7	Analysis of Various Samples for the Presence of Metals	Kara L. Ciomperlik
8	(Report not received)	
9	Study of Radiation and Environmental Monitoring Procedures	Maria A. De la Cruz
10	A Study of the Effects of One Night's Sleep Loss on Physiological Data	Lisa E. Dillhoff
11	The Velocity Dependent Variations in the Magnetic and Electric Fields of a Charged Particle Moving at a Constant Velocity in One Dimension	Mark Eslinger
12	A Research Study of How Alcohol and Aviation Mix	Christine Fern
13	A Study of the Transfer of Perchloroethylene in the Milk of Lactating Mothers	D. Joshua Finch
14	Effect of Hypoxia on Respiratory Frequency, Heart Rate, and Oxygen Saturation in Human Males	Stephanie J. Garcia
15	Measuring Non-Linear Transmittance Properties of 1-Phenylazo 2-Naphthalenol Laser Absorbing Dye	Michael D. Gavornik
16	The Dosimetry Program	Jennifer C. Gonzales
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Report Number	Report Title	Author
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23	Processing and Preparing a Protocol Case for Final Pathological Analysis	April Marie Lopez
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26	A Test of Feature Conjunction and Feature Disjunction Tasks in Three Dimensional Space	Virginia A. Miksch
27	Investigation of Item Facets for Three Working Memory Tests	Rebecca C. Mortis
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31	Procedures Used in the Study of the Effects of Catheterization Surgery on the Stress Levels in Rats	Stephanie A. Rodriguez
32	The Effects of Melatonin on Diurnal Fatigue Levels	Carol A. Salinas
33	Comparison of Human Temperature Transducers	Paul Salinas
34	A Study on Postural Imbalance in Humans as Related to Ocular Dominance	Sarah Schanding
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36	A Study on the Effect of Hydraulic Fluid H-19457C on the Reproductive and Endocrine Systems	Ryan Q. Simon
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CROSS OVER POINT STUDY FOR THE PANASONIC UD-716 THERMOLUMINESCENT DOSIMETER READER

Katherine M. Arnold
Research Associate
Radiation Dosimetry Function

Brooks Air Force Base
San Antonio, Texas 78235

Final Report for:
Research and Development Laboratories
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research

August 1992

CROSS OVER POINT STUDY FOR THE PANASONIC UD-716 THERMOLUMINESCENT DOSIMETER READER

Katherine M. Arnold
Research Associate
Radiation Dosimetry Function
Armstrong Laboratory/Brooks Air Force Base

Abstract

The accuracy of a photon counter versus the accuracy of a frequency counter in measuring radiation exposure is an integral part of ensuring quality control. Quality control is necessary to maintain the standards set forth by the National Voluntary Laboratory Accreditation Program. A cross over point study provides a check of accuracy as well as precision in reporting data. In order to analyze the cross over point of the photon and frequency counters, eighty-five Panasonic UD 802 AT thermoluminescent dosimeters were exposed to various levels of gamma (Cesium-137) radiation. Results from a Panasonic UD 716 thermoluminescent dosimeter reader indicated that the crossover point is near 2400 millirem.

CROSS OVER POINT STUDY FOR THE PANASONIC UD-716 THERMOLUMINESCENT DOSIMETER READER

Katherine M. Arnold

Introduction

Radiation dosimetry is a program which monitors the radiation exposure to individuals working with x-ray equipment, radioactive materials, or any source of ionizing radiation. This monitoring includes, but is not limited to, hospital employees, nuclear reactor personnel, and calibration facility workers. The objectives for a personnel dosimetry program, as outlined by Bohm and Ambrosi, are as follows:

> (1) providing information for estimating worker exposure for regulatory compliance; (2) having a very wide dynamic range covering both minimal and life-threatening dose ranges in units relevant for post-accident medical care; (3) indicating the types and energies of the radiations; (4) providing workplace environmental information; (5) providing data for As Low As Reasonably Achievable (ALARA) program coordinators; (6) providing data on the adequacy of workplace designs, work procedures, and personnel training; and (7) providing data for future epidemiological studies, risk and benefit analysis, and medical and legal purposes. (Williams, p.586)

Dosimetry programs exist all over the country to ensure that occupational workers do not exceed standard limits of radiation exposure. Limits for radiation exposure were found by determining the minimum risk for harmful effects from radiation. The occupational limits are set lower than any risk factor. These limits are defined in Title 10 of the Code of Federal Regulations (CFR), Part 20, and utilized by the Nuclear Regulatory Commission. New limits for occupational workers are pending

approval. The proposed 10 CFR 20 defines the following radiation limits:

Total effective dose equivalent.	5 Rem
Deep dose equivalent plus committed Dose equivalent for any organ/tissue.	50 Rem
Eye dose equivalent.	5 Rem
Shallow dose equivalent	50 Rem
Extremity dose equivalent.	50 Rem

To maintain the level of quality necessary when dealing with an individual's health and safety, standards must be met within every dosimetry program. These standards are enforced by the National Voluntary Laboratory Accreditation Program.

The National Voluntary Laboratory Accreditation Program (NVLAP)

NVLAP is a part of the Department of Commerce and the National Institute of Standards and Technology. Its function is to accredit both public and private dosimetry laboratories by evaluating their technical qualifications and competence for conducting specific test methods in specified fields. (Gladhill, p.2) The fields in which NVLAP offers accreditation are also listed in American National Standard 13.11. The eight categories are:

I. Accidents, low energy photons
II. Accidents, high energy photons
III. Protection, low energy photons
IV. Protection, high energy photons
V. Protection, beta particles
VI. Protection, photon mixtures
VII. Protection, mixtures, photons, and beta particles
VIII. Protection, mixtures, fission neutrons and high energy photons.

The accident categories refer to dose levels which would directly result in short term injury or death. The protection

categories encompass low levels of radiation exposure which correspond to occupational exposures, resulting in long term health effects, i.e. cancer. NVLAP conducts biannual proficiency testing in each of the categories in which a laboratory wishes to become accredited. The accreditation is renewed annually as long as the laboratory proves itself to be worthy of recertification. According to the NVLAP Program Handbook, "To be granted accreditation, a processor must satisfy the NVLAP criteria and must also demonstrate proficiency in processing each dosimeter model/type it intends to use in each radiation category for which accreditation is desired, according to ANSI N13.11." (Gladhill, p. 12)

Because accreditation is so focused on performance of the laboratory, quality control is an integral part of maintaining a dosimetry program.

Quality Control

There are several types of quality control procedures for dosimetry. Dosimeter readers must be calibrated to a known exposure level. Calibrations are conducted for both the photon counters and the frequency counters. Badges irradiated to 300 mRem and 3000 mRem are used because these measurements incorporate both types of counters, therefore ensuring proper calibration. Daily checks of calibration and monthly calibrations are used to maintain quality assurance.

Proficiency testing is also important when evaluating the

competency of a dosimetry lab. When these tests are conducted, a radiation facility irradiates a certain number of dosimeters to varying levels in each of the NVLAP categories. Then the dosimetry lab conducts a comparative study, comparing the results of their readers versus the irradiation report from the radiation facility. This type of study provides a form of auditing for the dosimetry laboratory, and also provides a forecast of the performance on the NVLAP accreditation test.

Reader verification testing is also conducted to ensure that the readers are working properly. One such test is the cross over point study. This was the study conducted this summer on Reader #1 of the Air Force Personnel Radiation Dosimetry Function at Armstrong Laboratory and Brooks Air Force Base.

The Cross Over Point

In order to understand the methodology of the study, the cross over point must first be analyzed. When a thermoluminescent dosimeter (TLD) reader is reading a dosimeter, it is actually heating the elements to return metastable electrons back to their ground states. Energy is necessary to move an electron from a stable state to a higher metastable energy level, so when that electron moves back to a stable state, it releases energy. That energy is released in the form of photons (visible light). The more radiation the badge was exposed to, the more light the elements will release when read.

The photons released are then counted in the photomultiplier tube (PMT). The PMT has two types of electronic counters attached to it, a photon counter and a frequency counter. The photon counter is able to detect weak amounts of radiation (individual pulses of light). Light output is directly proportional to exposure, e.g. the more light that is emitted, the greater the radiation exposure. For large doses of radiation, the photon counter is not able to count the light output because the photon counter becomes saturated. Beyond the point of photon counter saturation, light measurement must be measured by the frequency counter. The frequency counter integrates the current created by the photomultiplier tube. The point at which the response in the photon counting system crosses the response of the frequency counting system is called the crossover point. A crossover point study must be accomplished on new readers immediately following installation, annually, or when, according to industry protocol, the reader's performance becomes questionable.

Methodology

To perform this study, eighty-five badges were issued for the study. Five were used as controls, and the remaining eighty were irradiated at the following levels:

Group 1	10 mRem
Group 2	100 mRem
Group 3	300 mRem
Group 4	500 mRem
Group 5	800 mRem
Group 6	1000 mRem
Group 7	1200 mRem
Group 8	1500 mRem

Group 9	2000 mRem
Group 10	3000 mRem
Group 11	4000 mRem
Group 12	5000 mRem
Group 13	7000 mRem
Group 14	10,000 mRem
Group 15	30,000 mRem
Group 16	50,000 mRem.

The TLD's were then read in a Panasonic UD-716 reader. A mean element correction factor report and a raw data report were generated using the system software. The element correction factor (ECF) varies for each element in every dosimeter. The ECF is calculated because the different elements respond with a different light output, according to the individual exposure. The response, however, is consistent, and the ECF provides a normalization so all results may be compared. The raw data report contains data strings which give different types of information. These are examples of the data strings:

```
2 59 02 74  01 200 0527003 7045 7048 7009 7006 002 010 0925  Y252
C7005704570007156 7010704870007154 7000700970070117000700670007008
```

The information needed for a cross over point study can be extrapolated from these data strings. In the first line, the 0527003 represents the dosimeter number. In the second line, referred to as the C-string, the four sets of numbers in turn contain four more sets of numbers. Each set of the C-string represents each of the four elements. The last three numbers of this four number set is the actual relevant data. The first number identifies the placement of the decimal point. For example, a seven at the beginning of a four-number data set represents 10^{-1}. In the first set the 7005, which has an actual

value of .5, represents the pre-heat flash of the photomultiplier tube. 7045, which is actually 4.5, represents the reading by the photon counter for Element 1. 7000 (actual value: 0.0) represents the reading by the frequency counter. The final four numbers represent the reading from a post-anneal flash by the photomultiplier tube. Annealing is a process which ensures that as many electrons as possible are returned to a stable state. This is another method of quality control.

Using all this information, several calculations were made.

Data

The data tables follow this page. The first column gives the serial numbers for the badges. The next four columns give the photon and frequency readings for each dosimeter. Initially, elements two and three were used for analysis because they are two different compounds. It was later discovered that only element 3 should be used because lithium borate (element 2) has forty times less light output than calcium sulfate (element 3). Lithium borate would therefore require a forty times higher delivered dose to drive the frequency counter.

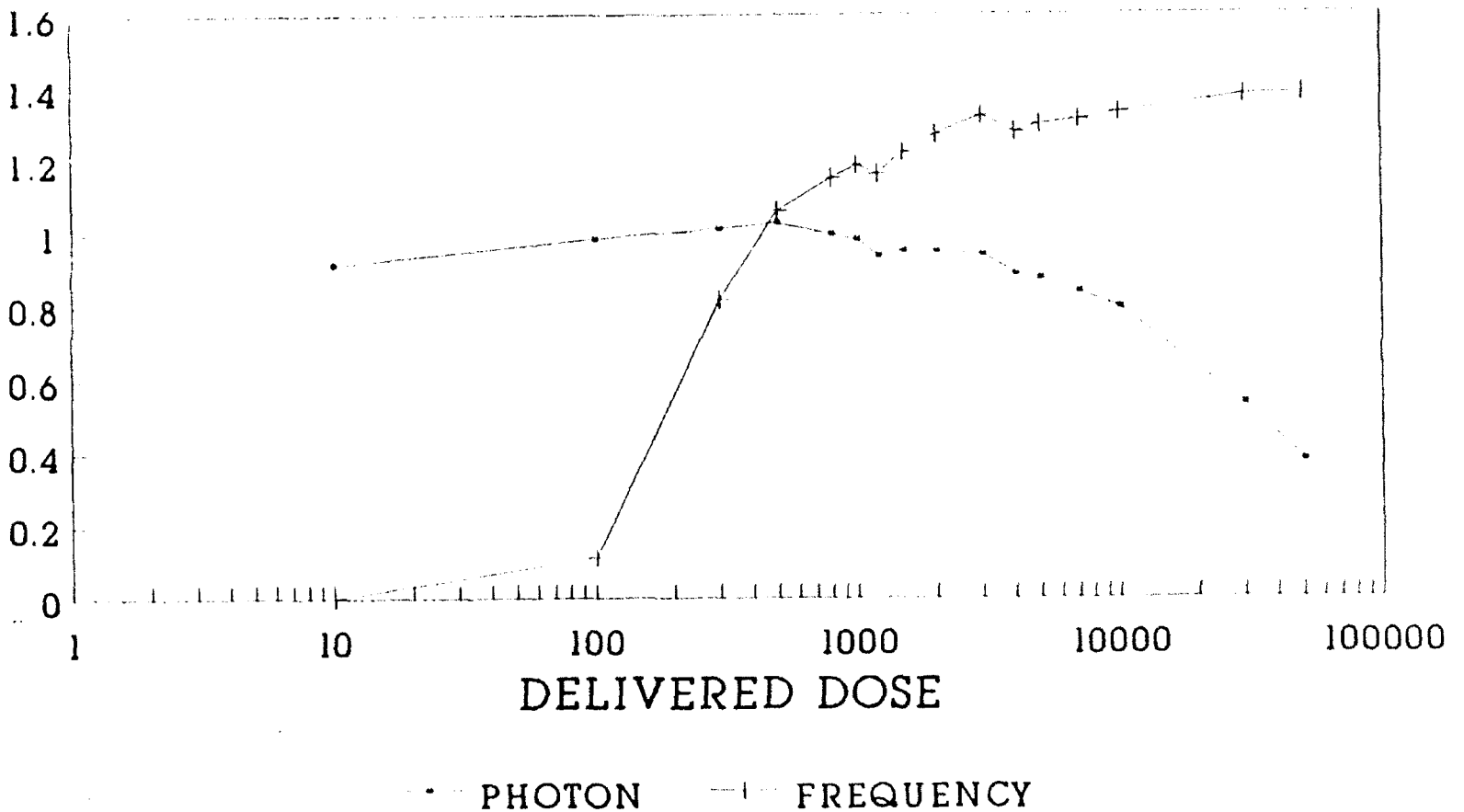
The next two columns are the element correction factors (ECFs) for each element. These numbers were divided into the original reading to get an ECF corrected number (columns eight through eleven). The next column gives the verification dose. This is the dose to which the badges were irradiated. The final four columns give the ratio for the photon and frequency

CROSS OVER POINT STUDY DATA-READER 1
JULY 1992

TLD #	PHOTON: CHIP 2	PHOTON: CHIP 3	FREQUENCY: CHIP 2	FREQUENCY: CHIP 3	ECFs: CHIP 2	ECFs: CHIP 3	ECF COR. PHOTON: CHIP 2	ECF COR. PHOTON: CHIP 3	ECF CORR. FREQ.: CHIP 2	ECF CORR. FREQ.: CHIP 3	VER. DOSE	PHOTON RATIO: CHIP 2	PHOTON RATIO: CHIP 3	FREQUENCY RATIO: CHIP 2	FREQUENCY RATIO: CHIP 3
0510673	5.800	3.400	0.000	0.000	0.819	1.047	7.082	3.247	0.000	0.000	CONTROL				
0506516	7.900	4.300	0.000	0.000	1.119	1.102	7.060	4.265	0.000	0.000					
0527003	10.300	3.100	0.000	0.000	0.967	1.017	10.436	3.048	0.000	0.000					
0521447	9.000	3.100	0.000	0.000	1.136	0.931	7.923	3.330	0.000	0.000					
0521448	9.000	2.900	0.000	0.000	1.193	0.909	7.544	3.190	0.000	0.000					
MEAN							8.009	3.416	0.000	0.000					
0505176	18.100	13.600	0.000	0.000	1.020	1.120	8.907	8.727	0.000	0.000	10 mRem	1.133	0.913	0.000	0.000
0507012	16.900	13.700	0.000	0.000	0.783	1.102	13.575	9.016	0.000	0.000					
0510621	14.400	15.000	0.000	0.000	0.735	1.206	11.583	9.022	0.000	0.000					
0507036	15.300	14.100	0.000	0.000	0.811	1.112	10.857	9.264	0.000	0.000					
0501006	19.300	13.800	0.000	0.000	0.968	1.057	11.929	9.640	0.000	0.000					
MEAN							11.370	9.134	0.000	0.000					
0507009	106.000	108.000	0.000	1.500	1.056	1.079	92.370	96.677	0.000	1.390	100 mRem	0.968	0.983	0.000	0.113
0505224	98.300	113.000	0.000	6.000	1.020	1.108	88.364	98.569	0.000	5.415					
0507035	89.800	107.000	0.000	0.000	0.856	1.010	96.898	102.524	0.000	0.000					
0508224	95.200	114.000	0.000	6.000	0.913	1.136	96.263	96.916	0.000	5.282					
0510642	91.800	122.000	0.000	13.600	0.876	1.200	96.786	98.751	0.000	11.333					
MEAN							94.136	98.591	0.000	6.684					
%CV							3.543	2.127	ERR	84.265					
0510676	260.000	330.000	0.000	260.000	0.858	1.039	295.022	314.197	0.000	250.241	300 mRem	0.982	1.012	0.000	0.816
0508801	189.000	341.000	0.000	273.000	0.638	1.102	288.229	306.021	0.000	247.731					
0510652	238.000	382.000	0.000	328.000	0.778	1.258	293.904	300.240	0.000	260.731					
0508225	356.000	322.000	0.000	250.000	1.160	1.079	298.888	295.008	0.000	231.696					
0509024	273.000	318.000	0.000	243.000	0.907	1.040	292.984	302.353	0.000	233.654					
MEAN							294.605	303.564	0.000	244.811					
%CV							1.294	2.108	ERR	4.430					
0507037	554.000	547.000	0.000	553.000	1.130	1.027	482.257	529.203	0.000	538.462	500 mRem	0.994	1.027	0.000	1.059
0507014	503.000	571.000	0.000	587.000	1.045	1.116	473.331	508.233	0.000	525.986					
0510679	397.000	555.000	0.000	567.000	0.778	1.055	502.274	522.650	0.000	537.441					
0510623	326.000	623.000	0.000	660.000	0.662	1.209	484.438	511.886	0.000	545.906					
0510677	401.000	524.000	0.000	523.000	0.727	1.049	543.573	496.107	0.000	498.570					
MEAN							497.175	513.616	0.000	529.273					
%CV							5.034	2.242	ERR	3.140					
0510627	489.000	939.000	0.000	1100.000	0.630	1.187	768.182	787.654	0.000	926.706	800 mRem	0.947	0.995	0.000	1.148
0508824	604.000	823.000	0.000	940.000	0.793	1.039	753.656	788.692	0.000	904.716					
0510680	623.000	848.000	0.000	975.000	0.789	1.021	781.598	827.142	0.000	954.946					
0510657	557.000	757.000	0.000	847.000	0.731	0.994	753.961	758.153	0.000	852.113					
0507025	784.000	903.000	0.000	1050.000	1.063	1.100	729.527	817.493	0.000	954.545					
MEAN							757.385	795.827	0.000	918.605					
%CV							2.290	3.071	ERR	4.157					
0508235	1050.000	1120.000	0.000	1360.000	1.079	1.178	965.114	947.348	0.000	1154.459	1000 mRem	0.924	0.980	0.000	1.185
0507023	791.000	1030.000	0.000	1240.000	0.877	1.077	893.930	952.944	0.000	1151.346					
0507040	954.000	1040.000	0.000	1250.000	1.015	1.040	931.893	996.584	0.000	1201.923					
0507038	748.000	1000.000	0.000	1200.000	0.790	0.992	938.827	1004.648	0.000	1209.677					
0505071	932.000	1100.000	0.000	1330.000	1.035	1.100	892.474	996.581	0.000	1209.091					
MEAN							924.448	979.622	0.000	1185.307					
%CV							3.009	2.482	ERR	2.244					
0508936	1180.000	1190.000	0.000	1470.000	1.073	1.008	1091.712	1177.139	0.000	1458.333	1200 mRem	0.899	0.935	0.000	1.158
0510638	975.000	1300.000	0.000	1630.000	0.890	1.166	1087.497	1111.507	0.000	1397.942					
0510662	839.000	1200.000	0.000	1480.000	0.771	1.073	1080.188	1114.944	0.000	1379.310					
0508974	1090.000	1080.000	0.000	1300.000	1.028	0.995	1083.105	1126.037	0.000	1402.472					
0510631	970.000	1300.000	0.000	1620.000	0.889	1.151	1078.961	1122.327	0.000	1389.918					
MEAN							1.287	2.765	ERR	3.542					
%CV															

TLD #	PHOTON: CHIP 2	CHIP 3	FREQUENCY: CHIP 2	CHIP 3	ECF's: CHIP 2	CHIP 3	ECF COR. PHOTON: CHIP 2	CHIP 3	ECF CORR. FREQ.: CHIP 2	CHIP 3	VER. DOSE	PHOTON RATIO: CHIP 2	CHIP 3	FREQUENCY RATIO: CHIP 2	CHIP 3
0508702	1450.000	1490.000	0.000	1900.000	1.045	1.034	1379.551	1437.590	0.000	1837.524	1500 mRem	0.909	0.949	0.000	1.220
0510634	979.000	1640.000	0.000	2120.000	0.699	1.180	1392.563	1386.414	0.000	1796.610					
0505149	1340.000	1590.000	0.000	2050.000	1.022	1.113	1303.146	1425.155	0.000	1841.869					
0509689	1180.000	1480.000	0.000	1890.000	0.855	1.003	1372.108	1472.157	0.000	1884.347					
0510667	1000.000	1470.000	0.000	1880.000	0.727	1.049	1361.507	1397.918	0.000	1792.183					
MEAN							1362.975	1423.847	0.000	1830.507					
%CV							2.281	2.130	ERR	1.844					
0509699	1970.000	1980.000	0.000	2630.000	1.062	1.022	1846.982	1933.962	0.000	2571.386	2000 mRem	0.911	0.948	0.000	1.268
0510664	1400.000	1960.000	0.000	2600.000	0.764	1.029	1824.452	1901.346	0.000	2526.735					
0509022	1670.000	2030.000	0.000	2720.000	0.905	1.069	1837.295	1895.555	0.000	2544.434					
0505073	1850.000	2160.000	0.000	2910.000	1.050	1.147	1753.896	1879.757	0.000	2537.053					
0510665	1510.000	1980.000	0.000	2640.000	0.816	1.057	1842.481	1869.810	0.000	2497.635					
MEAN							1821.021	1896.086	0.000	2535.847					
%CV							1.889	1.160	ERR	0.970					
0508939	3220.000	3080.000	57.100	4350.000	1.244	1.120	2580.416	2746.584	45.900	3883.929	3000 mRem	0.918	0.937	0.004	1.320
0502351	2530.000	2960.000	0.000	4160.000	0.885	1.050	2850.748	2815.631	0.000	3961.905					
0509679	2390.000	2980.000	0.000	4210.000	0.851	1.037	2800.452	2870.258	0.000	4059.788					
0508973	1880.000	2750.000	0.000	3850.000	0.673	0.978	2785.453	2808.445	0.000	3936.605					
MEAN							2754.267	2810.230	11.475	3960.557					
%CV							3.749	1.560	173.205	1.611					
0509173	2950.000	4010.000	0.000	5810.000	0.828	1.139	3554.793	3517.216	0.000	5100.966	4000 mRem	0.909	0.885	0.012	1.275
0510663	2990.000	3570.000	0.000	5070.000	0.778	0.984	3835.179	3624.633	0.000	5152.439					
0509537	3420.000	3910.000	228.000	5630.000	0.913	1.090	3737.884	3583.740	249.726	5165.138					
0508572	3060.000	3890.000	0.000	5610.000	0.874	1.108	3493.135	3507.414	0.000	5063.177					
0510632	3280.000	3970.000	0.000	5750.000	0.920	1.146	3557.209	3460.807	0.000	5017.452					
MEAN							3635.640	3538.762	49.945	5099.834					
%CV							3.549	1.644	200.001	1.080					
0509624	3580.000	4680.000	228.000	6940.000	0.818	1.086	4368.519	4305.976	278.729	6390.424	5000 mRem	0.905	0.874	0.156	1.296
0509514	4590.000	4600.000	1200.000	6810.000	0.985	1.066	4651.890	4311.781	1218.274	6388.368					
0508923	3910.000	4380.000	514.000	6430.000	0.835	0.977	4674.626	4479.695	615.569	6581.372					
0508523	4900.000	4900.000	1420.000	7320.000	1.131	1.123	4324.440	4359.896	1255.526	6518.255					
0509023	3860.000	4580.000	399.000	6780.000	0.838	1.040	4598.196	4400.430	476.134	6519.231					
MEAN							4523.534	4371.556	768.846	6479.530					
%CV							3.257	1.466	51.642	1.189					
0509623	5180.000	6230.000	1820.000	9730.000	0.757	1.006	6834.792	6189.427	2404.227	9671.968	7000 mRem	0.912	0.835	0.375	1.309
0505059	6870.000	6610.000	3600.000	10400.000	1.140	1.146	6018.307	5764.472	3157.895	9075.044					
0509523	5630.000	6200.000	2250.000	9310.000	0.869	1.057	6470.702	5862.241	2589.183	9186.377					
0509333	5540.000	6000.000	2280.000	9310.000	0.894	1.055	6188.859	5683.788	2550.336	8824.645					
0508542	5360.000	6530.000	2020.000	10300.000	0.837	1.137	6395.814	5739.768	2413.381	9058.927					
MEAN							6381.695	5847.939	2623.004	9163.392					
%CV							4.335	3.082	10.570	3.058					
0509622	8090.000	8460.000	5190.000	14300.000	0.856	1.031	9442.926	8202.209	6063.084	13870.029	10000	0.914	0.792	0.593	1.328
0509574	8630.000	8360.000	5970.000	13000.000	0.887	1.033	9721.416	8058.300	6730.552	13500.482	mRem				
0509224	8430.000	7890.000	5570.000	13100.000	0.946	1.004	8903.196	7855.150	5887.949	13047.809					
0509172	7180.000	8490.000	4160.000	14300.000	0.797	1.105	9000.774	7679.842	5219.573	12941.176					
0505189	8730.000	8200.000	5390.000	13700.000	1.009	1.050	8644.122	7806.108	5738.355	13067.619					
MEAN							9142.487	7920.322	5927.903	13281.423					
%CV							4.239	2.353	8.270	2.650					
0509607	22100.000	16900.000	24000.000	43200.000	0.805	1.019	27693.855	16581.471	29813.665	42394.504	30000	0.886	0.530	0.960	1.374
0509255	28100.000	17100.000	31600.000	45200.000	1.062	1.094	26451.502	15627.297	29755.179	41336.271	mRem				
0509722	19500.000	15800.000	20000.000	37600.000	0.758	0.958	25717.585	16489.277	26385.224	39248.436					
0507034	27100.000	17600.000	30300.000	48400.000	0.998	1.139	27146.300	15448.735	30360.721	42844.601					
0509849	23100.000	17000.000	24800.000	44800.000	0.894	1.112	25830.937	15284.354	27740.492	40287.770					
MEAN							26568.032	15886.227	28811.056	41218.316					
%CV							2.858	3.410	5.225	3.216					
0509222	40200.000	19800.000	48900.000	71200.000	0.933	1.050	43078.808	18853.727	52411.576	67809.524	50000	0.844	0.376	1.021	1.379
0509669	34700.000	19500.000	41000.000	67300.000	1.062	1.022	32666.191	19076.819	38606.403	65851.272	mRem				
0508624	35100.000	20100.000	41800.000	76200.000	0.793	1.115	44254.286	18023.490	52711.223	68340.807					
0507033	38500.000	19900.000	46700.000	75800.000	0.859	1.074	44811.549	18525.448	54365.541	70577.281					
0507032	42600.000	19900.000	52700.000	73700.000	0.922	1.022	46195.896	19468.208	57158.351	72113.503					
MEAN							42201.346	18789.538	51050.619	68938.477					
%CV							11.544	2.611	12.627	3.173					

CROSS OVER POINT STUDY
READER #1



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counters. These figures were calculated by taking the ECF corrected figure and dividing it by the verification dose.

Included in the table is the percent coefficient of variation. The coefficient of variation is the standard deviation expressed as a percentage of the mean. This number should always be $\pm$ 5%.

Following the data table is a graph of the information on the chart. The graph clearly shows that the photon counter's accuracy is linear up to a certain point, meaning that the photon counter maintained a certain level of accuracy for a period of time. The frequency counter begins at 0 and moves its way up to intersect with the photon counter. The actual cross over point is the mean of the two numbers at either end of the region where the photon counter is nonlinear and the frequency counter becomes linear.

By observing the graph of the data, it can be interpreted that the photon counter maintains accuracy up to approximately 3000 mRem. The frequency counter performance starts at zero and exhibits the desired linear response at approximately 1800 mrem.

Conclusion

The graph presents a region for the cross over point. To determine the actual cross over point, the mean of the two numbers at either end of the region must be determined. Therefore, the cross over point for the TLD reader is approximately 2400 mrem. The empirical cross over point,

reported by the manufacturer, is 2000 mRem. Allowances for the age of the PM tube, conditions surrounding the irradiation of the dosimeters, the calibration of the reader, and the age of the dosimeters are all credible factors which may have led to the variation in the data.

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THE STUDY OF GAS CHROMATOGRAPHY: VOLATILE ORGANICS

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THE STUDY OF GAS CHROMATOGRAPHY: VOLATILE ORGANICS

Esteban Arredondo

Abstract

Several uses and applications of gas chromatography were explored. The most explored application of gas chromatography was the sampling and analyzing of volatile organic compounds in potable water, non potable waste water, and soils (through specific Environmental Protection Agency extraction methods). The gas chromatagraph used was connected with other equipment required to perform a complete analysis as described by the EPA. Throughout the study, much knowledge about volatile organics and gas chromatography was obtained. Many problems were encountered making maintenance corrections necessary and allowing new insight about the gas chromatagraph and how it works.

THE STUDY OF GAS CHROMATOGRAPHY: VOLATILE ORGANICS

Esteban Arredondo

INTRODUCTION

Since the turn of the century, chromatography has evolved significantly to adapt with its new applications and now desired sensitivity and effectiveness. The change in technology, new scientific discoveries and arising environmental and biological problems has led chemists, biologists, botanists and other scientists to continue extensive studies in chromatography, the seperation of organic substances in biological materials. Faced with the challenge of developing new methods and techniques that surpasses the previos one, scientists have changed and improved chromatography drastically to where it is today Among the most advanced and widely used in gas chromatography. This technique seperates chemical substances from a sample by having analytes carried by an inert gas through a tube packed with absorbent material. Analytes are then seperated due to certain molecular properties such as size, weight and specific heat. The technique is widely used for quantitative and qualitative analysis of mixtures, purifaction of compounds and the determination of various substance amounts.

THE HISTORY AND EVOLUTION OF CHROMATOGRAPHY

The first applications of chromatography can be dated back to the

early dye chemists. These chemists tested their dye by dipping strings, a piece of cloth or filter paper into their dye. The solution would thus travel, through the use of capillary action, the length of the dipped material and seperate into different color bands. Later in the 19th century, German chemists dropped solutions of inorganic compounds onto the center of filter paper and studied the concentric, colored rings created as the solution spread through the paper. In 1861, this method was published and dubbed "capillary analysis." The discovery of chromatography, however, is attributed to a Russian botanist named Mikhail S. Tsvet. Tsvet noticed the physicochemical basis of the separation and applied it to the separation of plant pigments. Using a glass tube packed with sorbent material, Tsvet placed plant pigment washed with organic compounds to the top of the tube and let it run down forming different color rings according to the molecular weight. This method was published in 1910 and is the same concept used today. Since Tsvet worked with pigments, he called the method chromatography, a Greek word for color writing. Not until Richard Kuhn reported the resolution of a number of biologically important materials achieved by Tsvet's method, in 1931, that chromatography emerged as a major study.

A decade later, A.J.P. Martin and R.L.M. Synge, two British chemmist, started a study of amino-acids in wool. they applied different chromatographic methods and came up with the "liquid - liquid counter current distribution method" that later failed to give them adequate seperation. Because of this, they changed the method so that liquid was firmly bonded to a fine granulate solid packed in a glass tube and a second liquid. Here the sample was allowed to percolate through the tube where the compounds would seperate and bond to the granulate solid.

Although the method was mechanically identical to Tsvet's it was innovative because it involved the concept of a stationary liquid supported on a solid with a result that molecules seperated between the stationary liquid and a seperate modile liquid phase. This method was called "partition chromatography." The method presented several difficulties though. Lacking reproducibility in the properties of silica gel (sorbent material used) and lacking uniformity of the packed tubes, Martin and Synge again met the challenge and worked on a new procedure where the stationary medium was filter paper. The technique gave the desired reproducibility and in the 1940's became widely used thus replacing Tsvet's methods.

In the 1950's, Martin again explored a new method along with A.T. James. They reported the creation of gas chromatography. Small particles of support material was coated with a non-volatile liquid and packed in a heated glass tube. Mixtures were injected into the column and driven by compressed gas. The gas would then appear in separate zones. A major advance came to this method with the elimination of the support material and the coating of the liquid in the wall of a long capillary column. As a result, it is possible to seperate a larger number of components.

APPLICATIONS

Gas chromatography has been used to solve many problems in a wide range of areas. Among the most common are environmental and biomedical analysis. Due to the rapid growth of industry, its products and by-products are found in the water, air and soil. Many of these sometimes dangerous substances go undetected for long periods of time causing

contimination of the environment and its inhabitants. In recent years, though, chemists and environmental engineers have studied the never ending environmental problems. With early detection and analysis of environmental pollutants and health hazards, through the use of gas chromatography, corrective measures may be taken to ensure a future of the environment.

Many biological analysis and experimentation of various body fluids and foods have been done through the use of gas chromatography. Several of these studies have included amino acids, steriods, carbohydrates, and natural and synthetic foods. For instance, natural and synthetic foods are compared to assure similarities in composition. Further more, gas chromatography detects pesticides and othe contaminats such as carcinogenic compounds. With these biological studies, the safty and understanding of the human body has been imporved.

EPA METHODS

Because of the importance of gas chromatography in environmental studies, the EPA has developed and monitored special methods that can detect specific analytes. Method 502.2 is one of these specialized methods. The general purpose method is most often used to identify and measure volatile organic compounds in treated drinking water and raw source water. This method may be applied to a diverse range of organic compounds which include benzene, carbon tetrachloride, and trihalomethane disinfection by-products that have high volatility and low water solubility. These are just a few of many analytes.

Components are extracted from an aqueous sample by purging an inert gas through it. After purging, the sample components are trapped in

a tube packed with absorbent material where it is heated and backflushed into a capillary gas chromatography column. The column is temperature programmed to seperate the analytes through the use of specialized detectors. The identification of the analytes are confirmed by analyzing laboratory standards under the same conditions and by comparing the time the sample remains in the column before it is detected. This time is called the analyte's retention time.

Several other methods such as 601, 602, VOA (Volatile Organic Aromatics) and VOH (Volatile Organic Halocarbons) detect other analytes. These methods and others work by using the same concept. The difference between these methods is the equipment used. The purge and trap system and detectors may be different or connected in a different series so that the sample is heated or purged at different times.

EPUIPMENT FOR GAS CHROMATOGRAPHY: LAB USE

The gas chromatography system is very complex. The field of chromatography continues to change taking the technology of gas chromatography with it. One of the most general systems will be described in the following. In fact, the system described is one of the most commonly used in the lab.

The Tracor Model 540 consists of a column oven, a control unit, an inlet for one column, a detector, a flow controller for carrier gas and a needle valve/rotameter module. The column oven operated at temperatured from 400 degrees celsius down to -90 degrees celsius and has room for two columns. The oven and column is coooled after each run by cool forced air for rapid return to the initual start temperature. The system is equipt with a convenient control display for easy monitoring

of the oven temperature and operation time.

The purge and trap system is made up of three components: The purging tube, the trap, and a desorber. Certain specifactions of the components must be met before initial use with the Tracor 540 gas chromatograph. First, the all glass purging tube must be capable to hold 5 ml of sample and have a water column that is 5 cm deep. A small frit must be installed at the base of the sample chamber so that the desired purging gas may flow through the sample. Second, the trap also must be at least 25 cm long and have diameter of .105 inches. From the inlet to the outlet, the trap must contain specific absorbent materials depending on the type of test to be run. Before each use, the trap should be conditioned for 10 minutes at 180 degrees celsius by back flushing with an inert gas flow of at least 20 ml/minute. Finally, the desorber must be able to rapidly heat the trap to 180 degrees celsius. The actual purge and trap system used was the PTA-30 (Purge and Trap Auto Sampler) which meets the requirements. This system is designed to automate the sample handling procedures associated with the analysis for volatile organic compounds (VOC'S). The system is linked to computer software that can easily be accessed and modified to accomidate the method run. The program automatically removes samples from a 40 ml vial, adds an internal standard, transfers the sample to the purging device, initiates a run, drains and cleans the tube and goes to the next sample. A unique function of the system is that it automatically runs blanks from a blank/wash water solution so that any contaminats may be flushed. In more detail, once the samples is in position, the syringe needle pierces the septum of the capped vial and pressurizes the sample bottle. The syringe then transfers more sample than is necrssary in order to

to backflush a small filter in the upper end of the needle. Next, 1 ul of "standard" is injected into the sample through a rotary valve as the sample is being transferred to the purging tube. In the purging tue, the sample is purged by helium gas flowing at 40 ml/minute and ca carried into the trap where it is desorbed and then pushed through the column where the detectors complete the analysis.

The two major detectors used in the lab were the Photo Ionization Detector (PID) moded 703 and the Hall Edectroconductivity Detector (HALL) model 1000. The first detector has ultraviolet radiation as its source of energe. In this detector, photons having energy levels above 9.5 volts are emitted by a sealed gas filled discharged lamp. The photons enter the sample chamber and interact with the sample and any analytes that may be in it. Any compound with ionization potentials lower than the photon energy can become ionized and the resulting ions are collected and measured using a standard electrometer. A small fraction of column effluent is ionized by the ustraviolet radiation giving the detector a non-destructive property. The non-destructive nature of the PID allows operation of the PID in series with other detectors such as the HALL detector. Connections are made by a sample outlet tube to a nickle outlet extention that carries the detector effluent back down to the gas chromatograph oven. Finally, a length of fused silica tube is used to carry the sample to the HALL detector.

The second detector used was the Hall Electorconductivity Detector (HALL) model 1000. This detector is highly sensitive to volatile organic halogens, but it is an element specific detector that responds to all organic compounds. An effluent from the gas chromatograph enters the reactor while a nickle tube isheated. Next, a reaction between the desired

compound and the hydrogen reaction gas is catalyzed by a nickle tube with the result that most of the desired compound exists the tube in a different form. In the cell, the gas is brought into contact with n-propanol solvent in which the compound dissolves, increasing the conductivity of the solvent. The gas exists down the center of the cell while the solvent clings to the walls and is thus introduced into the conductivity measurment cell. Finally, the information detected is sorted and passed to the computer as a chromtagram.

ROUTINE LABORATORY PROCEDURES

The volatile organics lab must be carefully monitored daily to ensure accurate results for all analysis done on water samples and soil samples. Samples are delivered and must be checked and reviewed to prevent any detection of unwanted components. First, all samples must arrive chilled. The 40 ml vials are checked for air bubbles and inverted septa to prevent any contamination or inaccuracy of the gas chromatograph. An Occupational Environmental Health Laboratory sample number and a base sample number is assigned to all samples and placed in a folder. A final due date must be obtained by seeing when the sample was collected. Samples are allowed a 14 day holding time starting from collection date. If the sample is not analyzed before the deadline, there may be innaccurate results. Next, the information obtained and written on the folder is logged into a computer spreadsheet that helps keep records of what goes in and out of the lab. After this has been done, they are numbered and

stored in a refrigerator until they are to be analyzed. The refrigerators must also be monitored twice each day, in the morning and afternoon. The refrigerator temperature is allowed to range from 2 to 10 degrees C and must be kept constant so that analytes do not escape from the vial.

Laboratory standards and blanks are done before each test. All blanks are prepared with millique water (very pure deionized water). They are treated and analyzed as a regular sample and result in the chromatogram as a straight line with one peak, the surragate. Laboratory standards are also prepared in thesame manner. To prepare them, blanks are spiked with a known amount of analytes. Depending on the concentration, different amounts of control is used. For instance, the desired concentration for 40 ml vial may be 2 ug/L or 20 ug/L. This equals to 8.8 uL and 88 uL of control per blank respectfully. Before the spike, the syringe to be used is cleaned and flushed with methanol. An excess amount of control is extracted from its container in order to eliminate any air bubbles in the syringe. Now, the control is injected into the blank by piercing the septa which immediatly closes after the needle is removed. These procedures must be done on a routine basis to help monitor the gas chromatograph and to compare the analytes for accuracy.

Many times, a sample to be analyzed man contaminate the gas chromatography unit. If there is any suspition of this due to appearance of the sample, a dilution must be made. All dilutions are made in the same manner depending on the dilution ratio. A 1:10 or 1:50 dilution ratio is usually done depending on the sample's appearance. For a 1:10 dilution ratio, 5 ml of sample is added to a 50 mL flask. The flask is then filled with 45 ml of millique water. To ensure that there is ad-

equate mixing of the solution, the flask is inverted three times and then poured into a 40 ml vial.

Other procedures that may have to be done before the sample is to be analyzed is a soil extraction. For this procedure, a 50 ml vial, 50 ml flask, a 1 ml pipet and a 40 ml vial is needed. The first step is to weigh 2 grams of the soil sample and put it in the 50 ml vial. Next, methonol is poured into the remainder of the vial for at least one minute. This step mixes the analytes equally throughout the vial. One ml of the mixture should be extracted and then poured into the 50 ml flask. Exactly 49 ml of millique water is nowadded and inverted three times for mixing. Finally, the sample is poured into the 40 ml vial and analyzed as a regular sample.

Throughout the study, many problems were encountered. Some were minor set backs that could be corrected by the technician. Other times an expert was sent to pinpoint the problem and correct it. The minor problems encountered could usually be detected by seeing the chromatogram. Many times these minor problems were corrected at the same time by simply flushing the purge and trap system with blanks and cleaning the lamp. Other corrective measures that should be taken to prevent further set backs are a leak check, and the conditioning of the trap and baking of the column. These are just a few of the many problems that had to be overcome during the study.

CONCLUSION

Many things were learned throughout the study. With the changing of the world, gas chromatography, as it is today will soon be outdated. All hope is not lost though. To this point, gas chromatography has helped

give better understanding of the environment and the human body. Perhaps in the near future, gas chromatography will lead the way to solving environmental problems and help prevent sickness and disease.

Dermal Penetration of Dibromomethane

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Final Report for:
AFOSR Summer Research Program
Armstrong Laboratory

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Dermal Penetration of Dibromomethane

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Abstract

The absorption rate of dibromomethane was measured. This was accomplished by inserting a cannula into the external jugular vein of each anesthetized rat to be studied, and a glass cell was fixed to its back with adhesive. After 24 hours of recovery from surgery a solution of dibromomethane and mineral oil was injected into each cell. Blood samples were drawn through the cannula immediately before dosage and again after 1/2 hour, 1 hour, 2 hours, 4 hours, 8 hours, and 24 hours. The extracted blood was added to hexane,which removed the dibromomethane from the blood. The vials containing blood and hexane were put in the vortex evaporator for 15 minutes. After 15 minutes the hexane and dibromomethane were extracted off the blood and injected into autosampler vials. The samples were then analyzed on the gas chromatograph to determine the concentration of dibromomethane in the hexane. This concentration value depicts the amount of dibromomethane that was absorbed into the bloodstream.

Dermal Penetration of Dibromomethane

Sara Berty

Introduction

Safety in the workplace has become a greater concern in rccent years. In order to maintain safety, chemical intake rates must be measured and exposure limits set.

Workers are exposed to chemicals through three primary routes: dermal penetration, inhalation, and oral ingestion. It is often forgotten that the skin does not form a complete barrier against chemical entry; because of this, respiratory protection is often used, but the skin remains exposed. Chemicals are often absorbed or metabolized in the epidermis (only highly reactive compounds metabolize significantly (Bronaugh 255.))

The purpose of this experiment is to determine the rate of chemical absorption through rat skin. In the future this information will be used to determine the absorption rate of human skin.

Methodology

On July 13, eight rats were anesthetized. Each rat was injected with one-tenth of a milliliter of ketamine xylazine per 100g of body weight. Cannulas made from silastic tubing were then inserted into each rats' right external jugular vein. After the cannulization was complete and the rats were still under anesthesia, a glass cell was affixed to their backs with adhesive. The rats were then returned to their cages.

On the morning of July 14 a standard curve was made up (see Appendix A). Each rat was then checked to ensure that tthe cannulas were still patent. A dosing solution was made up from 3.5 ml of dibromomethane and 10.5 ml of

mineral oil.

Two milliliters of dosing solution were placed in each cell. One-tenth of a milliliter of blood was taken from each rat immediately before dosage and again after 1/2 hour, 1 hour, 2 hours, 4 hours, 8 hours, and 24 hours.

After the blood was drawn, it was extracted into vials containing hexane. The samples were then placed in the vortex evaporator for 15 minutes. After 15 minutes, the samples had separated into two distinct layers. The top layer was dibromomethane and hexane. The bottom layer was blood. The dibromomethane and hexane layer was drawn out of the vials and extracted into autosampler vials. These vials were then analyzed on the gas chromatograph.

The gas chromatograph gives the area counts of a sample. These area counts are used in the following equation to determine the concentration of dibromomethane in the sample.

$$(((X - 960.06)/63933.3)/E*D)$$

Key:

X= Area count

E= 89%; the extraction efficiency- the percentage of dibromomethane removed from the blood by the hexane after 15 minutes on the vortex evaporator.

D= dilution factor, 50

63,933.3= the slope of the standard curve

960.06= the y-intercept of the standard curve

Results

Rat No.1 Lot K61 male 211g dosed at 845

Time Point	Time Drawn	Area Counts	Conc. (ug/ml)
0	0815	75.45	0
1/2	0910	12,200.5	9.88
1	0944	23,727.2	20.01
2	1043	48,369.2	41.66
4	1238	81,101.3	70.42
8	1640	110,479.0	96.24
24	0757	113,782.0	99.14

Rat No.2 Lot K61 male 193g dosed at 0847

Time Point	Time Drawn	Area Counts	Conc. (ug/ml)
0	0815	77.97	0
1/2	0914	13,926.2	11.39
1	0945	35,835.4	30.65
2	1045	46,340.0	39.88
4	1240	50,256.8	43.32
8	1643	62,135.5	53.76
24	0759	45,575.1	39.20

Rat No.3 Lot K61 male 250g

Rat No.3 would not draw.

Rat No. 4 Lot K61 male 226g dosed at 0848

Time Point	Time Drawn	Area Counts	Conc. (ug/ml)
0	0815	no peak	0
1/2	0918	16,967.8	14.07
1	0950	39,802.9	34.13
2	1049	cannula pulled out of rat	
4	1245	--	--
8	1645	--	--
24	0801	--	--

Rat No. 5 Lot K61 male 244g dosed at 850

Time Point	Time Drawn	Area Counts	Conc. (ug/ml)
0	0815	83.41	0
1/2	0918	30,312.1	25.79
1	0950	67,089.1	58.11
2	1049	86,957.7	75.57
4	1245	132,761.0	115.82
8	1645	144,577.0	126.2
24	0801	19,651.3	16.42

Rat No. 6 Lot K61 male 223g Dose at 0851

Time Point	Time Drawn	Area Counts	Conc. (ug/ml)
0	0815	93.61	0
1/2	0921	6,164.27	4.57
1	0952	18,876.9	15.74
2	1051	35,878.4	30.68
4	1246	72,840.2	63.16
8	1647	84,477.0	73.39
24	0803	61,805.2	53.47

* At the 24 hour point the rat appeared to have damp skin, but fluid remained in the cell.

Rat No.7 Lot K61 male 227g Dosed at 0852

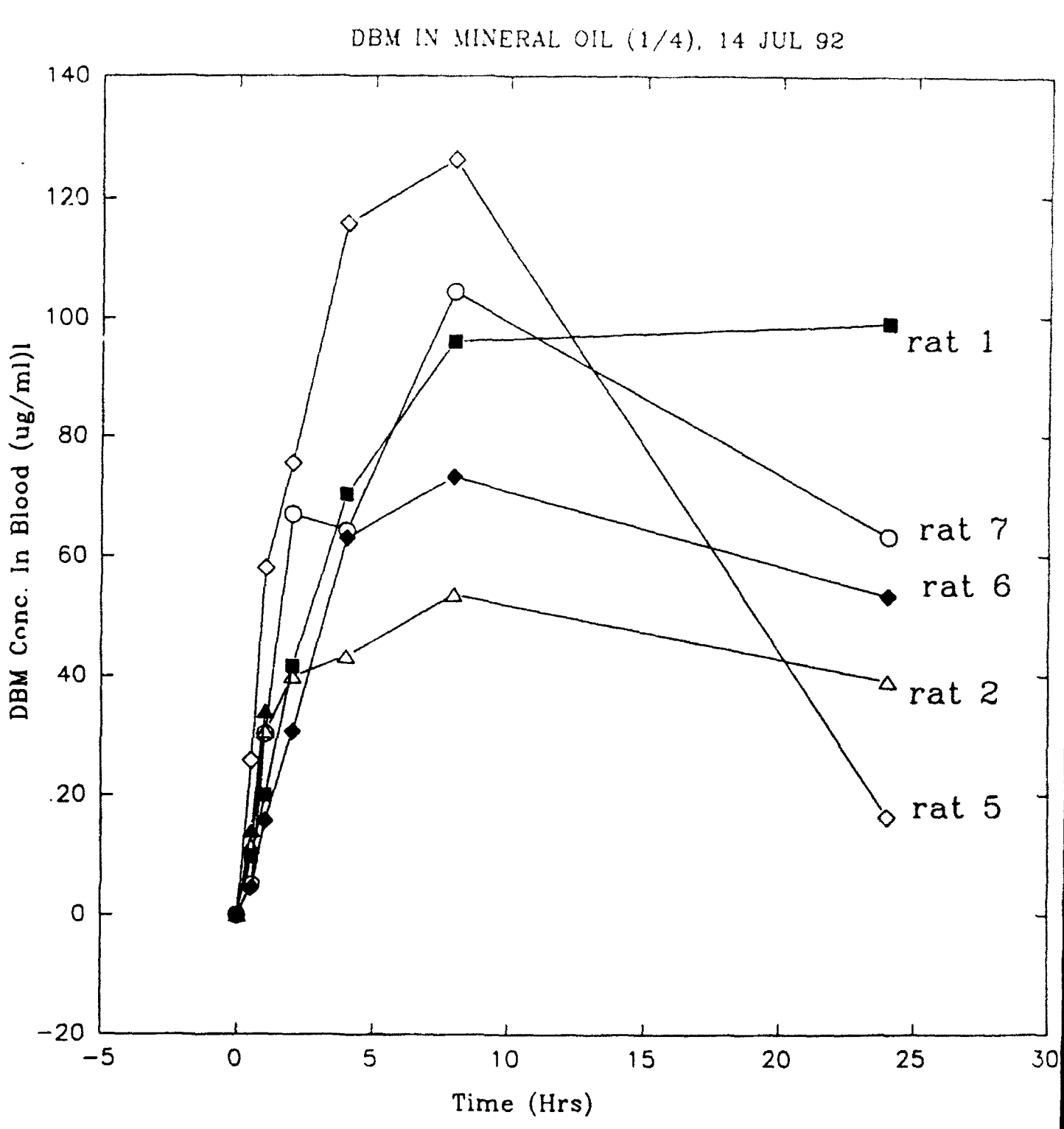
Time Point	Time Drawn	Area Counts	Conc. (ug/ml)
0	0815	113.65	0
1/2	0926	6,656.65	5.01
1	0955	35,435.5	30.20
2	1053	77,247,7	67.04
4	1250	74,102.1	64.24
8	1652	119,878,0	104.5
24	0807	73,014.8	63.32

* At the 4 hour point the rat appeared to have damp skin.

-At the 24 hour point fluid remained in the cell, but the rat was euthanized to obtain blood.

Rat No.8

Rat No.8 died on July 13.


DBM IN MINERAL OIL (1/4), 14 JUL 92
DBM Conc. In Blood (ug/ml)]
Time (Hrs)
140
120
100
80
60
40
20
0
-20
-5
0
5
10
15
20
25
30
rat 1
rat 7
rat 6
rat 2
rat 5

Appendix A

Standard curve calculations:

Stock solution = 8 ul DBM + 10 ml hexane = 1980 ug/ml

100 ug/ml = .505 ml STK + 9.495 ml hexane

5 ug/ml = 250 ul 100 + 4750 ul hexane

4.5 ug/ml = 900 ul 5 + 100 ul hexane

4 ug/ml = 800 ul 5 + 200 ul hexane

3.5 ug/ml = 700 ul 5 + 300 ul hexane

3 ug/ml = 600 ul 5 + 400 ul hexane

2.5 ug/ml = 500 ul 5 + 500 ul hexane

2 ug/ml = 60 ul 100 + 2940 ul hexane

1.5 ug/ml = 750 ul 2 + 250 ul hexane

1 ug/ml = 30 ul 100 + 2970 ul hexane

.75 ug/ml = 750 ul 1 + 250 ul hexane

.5 ug/ml = 500 ul 1 + 500 ul hexane

.25 ug/ml = 250 ul 1 + 750 ul hexane

.1 ug/ml = 100 ul 1 + 900 ul hexane

Checkpoints

4 ug/ml = 40 ul 100 + 960 ul hexane

2 ug/ml = 400 ul 5 + 960 ul hexane

1 ug/ml = 500 ul 2 + 500 ul hexane

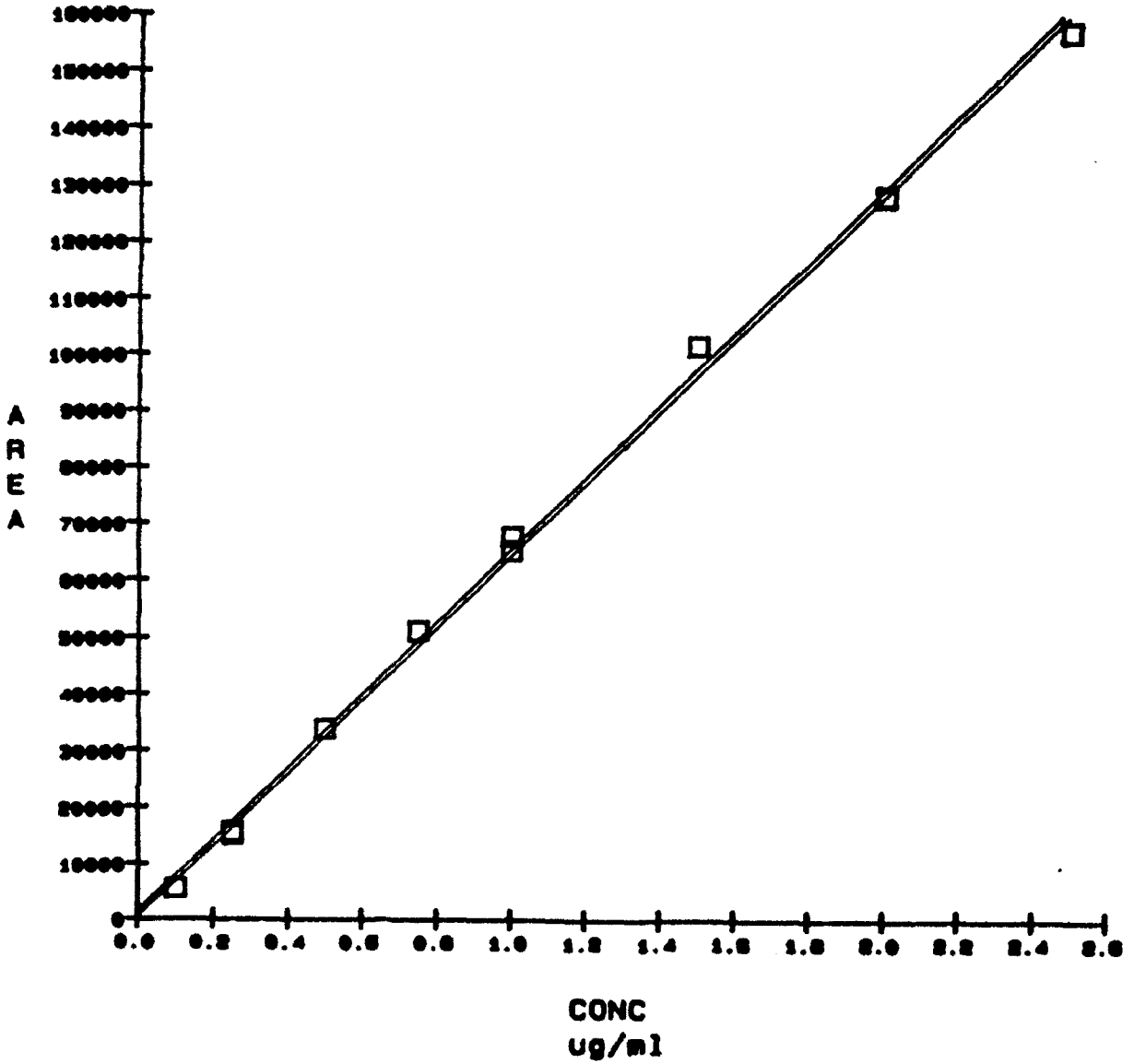
.25 ug/ml = 50 ul 5 + 950 ul hexane

.1 ug/ml = 50 ul 2 + 950 ul hexane

DBM14JULLO
2 13:56 Page 1

29-JUL-9

DBM STD CURVE 14 JULY 1992
(0.1-2.5ug/ml)



63933.300538*X +960.055715

3-10

Conclusions

This project is only in its preliminary stages. In the future the information obtained from these experiments will be used in a physiologically-based pharmokinetic (PBPK) model. The PBPK model will predict the effect of the chemical on humans and the amount of the chemical absorbed by using animal data.

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PATHOLOGY LABORATORY OVERVIEW

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FINAL REPORT FOR:
SUMMER RESEARCH PROGRAM
ARMSTRONG LABORATORY

SPONSORED BY:
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
BOLLING AIR FORCE BASE, WASHINGTON, D.C.

AUGUST 1992

PATHOLOGY LABORATORY OVERVIEW

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ABSTRACT

The three laboratories included in the Comparative Pathology Branch interpret and calculate all protocol results involving tissue samples. Necropsies, tissue processing, and staining procedures are performed by the Anatomic Pathology Laboratory. Clinical Pathology provides diagnostic results from blood and culture samples. Electron Microscopists process and prepare tissue for the transmission and scanning electron microscopes. Comparative Pathology is a major contributor to the completion of studies. Only these highly trained specialists are able to interpret, and to some degree predict the changes in tissue structure and function future environments may cause.

PATHOLOGY LABORATORY OVERVIEW

Leah Elena Brown

INTRODUCTION

The Comparative Pathology Branch is one of the most important branches on Brooks Air Force Base. The effects and results of controlled studies and experiments on tissue are interpreted here. Studies are conducted using research specimens. The specimens are used to give designers, engineers, healthcare providers, and many others involved, the possible effects on man in future environments, such as space travel, fighter aircraft cockpit environments, and even future battlefield environments.

METHODOLOGY

Before protocol specimens can be analyzed, an anatomic pathologist must remove the tissue. These samples are taken according to protocol and immediately placed in formalin or other fixatives. This preserves the tissue. After a 24 to 48 hour period, the tissue is removed from formalin, examined grossly, and deposited in cassettes. Gross examination is a technique by which a large sample is cut into smaller, easier to process pieces. After the tissue is grossly examined, it is sent through a tissue processor.

A tissue processor prepares the tissue for embedding, by sending it through a series of chemical solutions. First, it is placed in Pen-Fix, a solution that further fixes the tissue. Histoclear and Clear-Rite, the next series of solutions, clears it of all fixatives. Alcohol then dehydrates the

tissue.It clears the Histoclear and Clear-Rite and prepares the sample for the last step. The tissue is then impregnated with paraffin wax. The tissue can now be embedded in paraffin wax.

When placed in the embedding unit the tissue will be completely surrounded by hot paraffin wax and allowed to cool on the cryo console forming blocks. The Cryo console remains at a constant temperature of $-2^{o}C$. After the block has cooled, it is cut by a microtome. The microtome is usually set to cut four to six microns thick. The sections are then removed from the microtome blade in a ribbon, and gently placed in a water flotation bath. The best section is chosen and mounted on to a slide.

When the slides for an entire protocol case are cut and mounted, they are allowed to dry. The slides are heated to melt away the paraffin. Heating also prepares the tissue for the staining process.

The most common stain used is the Hematoxylin and Eosin stain (H&E). First, the slides are run through four changes of Histoclear to remove any paraffin that remains after being heated. Next, three changes of absolute (200 proof) alcohol remove the Histoclear and dehydrate the tissue. The next two changes of 95% alcohol rehydrate the tissue. The slides are washed in water and placed in hematoxylin stain. After the slides have remained in hematoxylin for six minutes, they are washed in water and quickly dipped in 1% acid/alcohol to remove any excess hematoxylin. The tissue is then immersed in saturated lithium carbonate to enhance the bluish color of the hematoxylin stain, and washed in water to remove the excess lithium carbonate. Ninety-five percent alcohol prepares the slides for the eosin stain. They are stained a pinkish color by the eosin for 30 seconds. A series of alcohol solutions

follow the eosin stain. Before the coverslip can be placed, it must go through four changes of Histoclear. Once the slides are coverslipped with a mounting glue, they are properly labeled and given to a pathologist for microscopic diagnosis.

Medical laboratory technologists in the Clinical Pathology Laboratory also provide information to pathologists. Technicians perform blood and bacteriology tests on protocol case studies. A Coulter counter performs a Complete Blood Count (CBC), which includes the number of red and white blood cells and platelets. Chemical tests are also performed on serum. These tests measure the amounts of minerals, proteins, enzymes, and cholesterol in the bloodstream.

The light microscope plays a very important part in the work of a medical technician. Slides prepared from cultures or feces are stained and examined under the microscope to identify organisms such as cryptosporidium oocysts. Oocysts are the infectious form of the parasite cryptosporidium which causes diarrhea and may lead to malnutrition and even death. Microscopes are also used to identify different types of white blood cells on a blood smear. But before a blood smear can be examined it must be stained with Wright's Differential, which stains the nucleus of the white blood cells. This procedure makes the white blood cells easier to distinguish. Electron microscopists view tissue samples at a much higher magnification than an anatomic pathologist. Because of the magnification needed to view the tissue and handling difficulties, the work is very tedious. For viewing under a Transmission Electron Microscope (TEM), the tissue received from protocol must be minced into 1mm pieces and is immersed in Karnovsky's fixative for at least

two hours. Karnovsky's serves the same purpose as formalin but is much stronger and more dangerous. The tissue is washed in sodium cacodylate and then post-stained in osmium tetroxide for one hour. A series of alcohol solutions is used to dehydrate the tissue. Three changes of propylene oxide prepares the tissue for plastic infiltration. A 1:1 mixture of propylene oxide, plastic, and 1.4% DMP (catalyst) is added to the tissue. It is then embedded in pure plastic and allowed to harden at 30 to 60°C for three days. The hardened block is cut into sections one micron thick and stained with T-Blue stain. The pathologist looks at the slides and chooses which particular section of the block best demonstrates the lesions under study. The electron microscopist cuts away all tissue around the area of interest and then cuts thin sections 600 to 800 Angstroms (A) thick. Angstroms are extremely small. There are 10,000A in a micron and 1,000 microns in an inch. These thin sections are then mounted on to a copper grid.

Now grids are ready for the microscopist to view and photograph. Once the photographs are taken, the negatives and micrographs are developed in the darkroom and the electron micrographs are given to the pathologist for observation and analysis.

Conclusion

Anatomic Pathology, Clinical Pathology, and Electron Microscopy together interpret the results of protocols in such a way that other Armstrong laboratories can understand and apply the information. Without these interpretations by the Comparative Pathology Branch, the studies conducted on this base would be inconclusive.

DIETARY INTAKE PATTERNS AND CARDIAC EVALUATIONS OF UNITED STATES AIR FORCE PILOTS

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Final Report for:
Summer Research Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
Brooks Air Force Base, San Antonio, TX

August 1992

DIETARY INTAKE PATTERNS AND CARDIAC EVALUATIONS OF UNITED STATES AIR FORCE PILOTS

Carmen Casares
Internal Medicine Branch
Clinical Sciences Division
Armstrong Laboratory

ABSTRACT

The dietary intake patterns of pilots at Randolph Air Force Base are the focus of this study. Dietary intake was obtained to determine the consumption of calories and fat as compared to the National Cholesterol Education Program. In addition to this, the cardiac evaluations that pilots undergo were observed. Surveys and 24 hour dietary recalls were sent to two flying squadrons at Randolph AFB. The information returned by the pilots was reviewed and results were sent to those who requested them. Appointments were made for different days to observe actual cardiac evaluation procedures on patients.

Experimental results show that although the presence of coronary heart disease in the flying population is low, initial or additional dietary counseling and awareness could be sought. Pilots are grounded if their health is questionable and sent to the United States Air Force Armstrong Lab Clinical Consultation Service (AL/AOCI) for further evaluation. The cardiac evaluations benefit both the life and career of a pilot.

DIETARY INTAKE PATTERNS AND CARDIAC EVALUATIONS OF UNITED STATES AIR FORCE PILOTS

Carmen Casares

INTRODUCTION

Coronary heart disease (CHD) affects a large percentage of the American population. It is caused by artherosclerosis, a slow progressive disease of the large arteries that begins early in life but rarely produces symptoms until middle age. More than 550,000 deaths occur every year due to this disease. (1) Several risk factors have been strongly associated with CHD. Among these are smoking, high blood pressure, inactivity, overweight, and diet patterns.

Diet has been a very important factor in the prevention of CHD. The elevation of blood cholesterol levels leads to cholesterol deposits in the arteries. Therefore, the distribution and transportation of cholesterol in the blood is linked with the high risk of the development of coronary heart disease. The average American consumes approximately 37% of total caloric intake as fat. The National Cholesterol Education Program (NCEP) recommends no more than 30% of total calories from fat for the population. A further reduction of no more than 20% of total calories from fat with less than one-third of that from saturated fat will aid in reducing the progression of diesease, for those diagnosed with minimal coronary artery disease. (2)

STATEMENT OF PROBLEM

With the great investment in the selection and training of pilots, how can we insure these individuals remain safe to fly?

BACKGROUND

United States Air Force aviators receive annual medical evaluations and are expected to meet physical standards in order to remain on flying status. (3) Sixty percent of the patients referred to USAFSAM, Brooks AFB are suspected of cardiovascular disease. Due to the large investment in the training of pilots and the interest of the pilots to keep flying, it is important to keep them on flying status without risking their safety. All aircrew members referred to AL/AOC undergo a complete cardiovascular screening.

A complete cardiovascular screening includes myocardial imaging with thallium 201. Conducted under the supervision of a cardiologist, this heart stress test focuses on three main arteries: the right coronary, left circumflex, and left anterior descending arteries. Myocardial imaging with thallium 201 has been shown to be an accurate method of detecting coronary artery disease in asymptomatic patients. (4) Furthermore, it separates the asymptomatic men with abnormal treadmills into those with and without coronary artery lesions.

A patient needing a thallium heart stress test is asked to fast for the period after 7 p.m. of the night before the evaluation. Prior to the test, an IV is started and ECG leads and blood pressure cuffs are attached to the patient. Peak stress is reached on either a

treadmill or bicycle ergometer. At the time of maximum heart stress, the patient is injected with the imaging substance thallium 201. The patient then lays down on a scanning table. After the substance has concentrated in the heart muscle, the scanning process begins. This process consists of thirty-two pictures taken of the heart at 32 different angles, which takes approximately 30 minutes. After the initial process is completed, the patient is allowed to leave. Three to four hours later, the patient returns (without having consumed any food) to have only the scanning process conducted again.

Both sets of pictures (one set after exercise and one at resting heart rate) are compared. The images, visible on a computer monitor, are "sliced" in several manners, among these are: sagittal--slicing from right to left, coronal--slicing from top to bottom, and transversal--slicing diagonally. The pictures taken at maximum heart stress are compared to the ones taken at resting heart rate, with each picture being of the same portion of the heart as well as the same "slice". The results of this test will reveal wall motor defects and heart pump performance during increased oxygen demands.

An echocardiogram, a type of sonogram, is used to detect any abnormalities in the expansion and contraction of the heart atria and ventricles. Patients are instructed to lay down and a lubricant is applied to serve as a conductor. The examining technician, or the ultrasonographer, then applies device called a transducer to the patient's skin. A view of the heart atria and ventricles can be seen on a monitor by both the ultrasonographer and the patient. Testing

procedure can take from 1 hour to 1 1/2 hours.

Treadmill exercise testing is done on patients to detect any irregular heart rhythm during exercise. Patients exercise on a treadmill with ECG leads and blood pressure cuff attached to them. The treadmill is elevated about three degrees approximately every four minutes. This test, like the thallium, is conducted in the presence of a cardiologist. Testing time is approximately an hour, depending on the patient's physical condition.

In the case where any of the previous tests are failed, the patient is given the option to have a cardiac catherization. This procedure is optional, but if the pilot does not choose it he will remain grounded. Cardiac catherization is a method used to detect defects in the heart chambers, valves, and vessels. Catheters carry contrast material into the right and left sides of the heart. As the catheters are advanced, x-ray pictures are made visible on a television monitor showing the action of the heart. The material injected provides a definite structured view of the heart. Along with what is being done here, each coronary artery is filmed as well. An oscilloscope monitors the patient's heart rate, rhythm, and pressures. This procedure is very useful in determining the extent of heart damage and diagnosing congenital abnormalities.

METHODS

The lifestyle of aircrew is important in identifying risks of heart disease. A study focused on male pilots at Randolph AFB, TX between

the ages of 25 and 50. Initially, one hundred surveys were sent to two flying squadrons. The surveys consisted of questions concerning dietary intake, caffeine and alcohol intake, smoking, exercise, and work schedules. Of one hundred surveys, eighty-one were completed, with seventy-six having 24 hour dietary recalls. A registered dietitian, along with the aid of the Nutritionist III food data base, evaluated the dietary recalls. Those pilots who had requested the results of their personal dietary recall, were provided with a copy of their nutrient analysis.

RESULTS

From the information obtained through the surveys and dietary recalls, it is obvious that dietary counseling and knowledge could be useful to some pilots. Although, they are urged to eat healthy, their flying schedules make it difficult to do so. Although flight kitchens, do provide balanced meals, pilots often consume meals from fast food restaurants which can contain 65% of calories from fat. Considering this, it is important that they be reminded of consistent fat intake below 30% and the importance of nutrition.

Results from the recalls and surveys concluded that 94% of the subjects were non-smokers, 51% consume 2 or less alcoholic beverages per week, 93% knew their cholesterol levels with 79% having cholesterol levels under 200 mg, and 77% of the subjects stated that their meals usually consist of fish or poultry. To balance the good habits there were the not so good habits such as: 85% miss meals due to their

flying schedules. 51% stated that breakfast was kept to a small snack sized meal, and 85% have between 1 and 7 meals per week from a restaurant or snack bar, whose foods tend to be high in fat and cholesterol.

CONCLUSION

Coronary arteriosclerotic disease, or coronary artery disease (CAD), is the most common cause for grounding aircrew and the leading cause of nontraumatic death in USAF aircrew members. (4) Due to the demands of a fighter pilot's duty, medications are unacceptable. Therefore an alternative method in treating and/or preventing CAD must be used. Studies conducted have found methods of detecting coronary artery disease. (5) For example, a study conducted at the USAF School of Aerospace Medicine concluded that HDL cholesterol levels help identify asymptomatic persons with a greater risk of having coronary artery disease.

Annually, the Internal Medicine Branch of the Clinical Sciences Division performs catherizations on 100 pilots. Although, a catherization does not guarantee that a pilot will regain flying status, post cath a pilot has a 75% chance of flying again. Basically, the evaluations performed save both the military and taxpayers money. The money saved amounts to $1.7 million for every pilot put back on flying status. After finding out how much is invested in each pilot, it is a relief to know that the prevalence of heart disease is low in the flying population. Further concluding that the overall health of the pilot population is better than that of the general population. (6)

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DOMESTIC TRENDS TO THE YEAR 2015

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Final Report for:
High School Apprenticeship Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, Washington, D.C.

August 1992

DOMESTIC TRENDS TO THE YEAR 2015

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Abstract

The following is a summary of the document prepared for the Army 21 project by the Library of Congress. The purpose of this document was to project domestic trends for the United States in the next 25 year time frame. The following areas were covered: demography, the economy, resources, education, society, technology, military science, and geopolitics and threat.

An infinite number of scenarios will affect future trends, many of which were discussed. However, this document assumes that there will be no world wars, nuclear wars, deadly viruses, or any type of crisis that could destroy a large portion of the United States population.

The United States is expected to go through a number of changes in a number of areas in the next 25 years. Without these changes, the United States could suffer drastically. Foreign competitors are emerging, and the United States is being challenged more that ever before. However, the United States has always been able to meet challenges of difficult situations, and come out on top.

DOMESTIC TRENDS TO THE YEAR 2015

Deborah A. Case

DEMOGRAPHY

The demography of the United States will go through many changes in the next 25 years. The total population in 1990 was 249.6 million, and is expected to reach 303.4 million by 2015. Most of the population growth will be growth in the ethnic minorities, primarily because of rapid immigration and high birth rate among the minorities. Many immigrants come to America from struggling unstable countries to escape poverty, and possibly to begin a career. However, if these countries become more stable in the next 25 years, there will most likely be a decline in immigration.

In the late 1980's there was an unusually high number of births. These high birth rates are not expected to continue because the fear of AIDS has caused people to reduce their number of sexual partners, and also because of the high number of abortions. The death rates are expected to stay about the same. The only change would be if there is an extraordinary find in medical science, or if a medical or political crisis hits the United States. AIDS is expected to move into the top ten causes of death in the United States, however a preventive vaccine will most likely be discovered in the next 25 years.

The Baby Boom generation is aging, and will begin to retire at the beginning of the next decade. The increase of the number of people over 66, and the slight decrease of those in the work force will mean that there are less workers to support more retirees. Social security, and other pensioners will suffer. To help improve this situation, the retirement age may be increased to 70. This is not unreasonable because the life expectancy has increased to 78.9 for men and 81.5 for women - nearly 6 years higher than that of the present - in which case people would be healthy enough to work longer.

In 2015, the recruitment-age group (18-25) will be large because of the high number of births in the late 80's, but this age group will make up only 10.7% of the total population compared to the 12% it makes up now. Because of
the aging population, the average soldier will be 30, supporting a family, and possibly a single parent. The armed forces will need to provide more services to support their soldier's social needs.

In 1990, ethnic minorities accounted for 28.2% of the total population. In 2015, this

Ethnic Group	1990		2005		2015	
	Number	%	Number	%	Number	%
White	180,250	71.8	187,436	66.4	190,702	62.8
Black	29,348	11.7	36,557	12.9	41,943	13.8
Hispanic	22,522	9.0	34,792	12.3	44,450	14.7
Asian	7,329	2.9	10,627	3.8	13,284	4.4
Indian	1,962	0.8	2,256	0.8	2,436	0.8
Other	9,451	3.8	10,665	3.8	10,629	3.5
TOTAL	250,862	100.0	282,333	100.0	303.444	100.0

Figure 1: Composition of U.S. Population
By Ethnic Groups (in thousands)

percentage will increase to 37.2% (See Figure 1). The Hispanic population, passing the black population, will become the leading minority and will make up 14.7% of the total population. One reason the black population will not remain the leading minority is because of the high death rate for blacks. Hispanics are generally younger, poorer, and less educated than those of other minorities, and the American society will have to make changes - such as education - to ensure that the Hispanics have opportunities to succeed.

In 2015, whites will represent 56.3% of the population for the 18-25 age cohort. This percentage is lower than the 67.1% in 1990 (See Figure 2). Due to the decreasing number of whites, the armed forces will recruit a smaller number of whites and a larger number of minorities. Many of these minority recruits will be Hispanic, and they will make up a larger percentage of the recruitment age population than in the past (See Figure 3). Many of these Hispanics are first generation Americans, and do not speak fluent English. The military will have to provide special training for Hispanics, and any minority for whom this applies, in areas such as the English language and the American culture. The military will also have to encourage acceptance of all minorities, however diverse they may be. In the past, the military has never

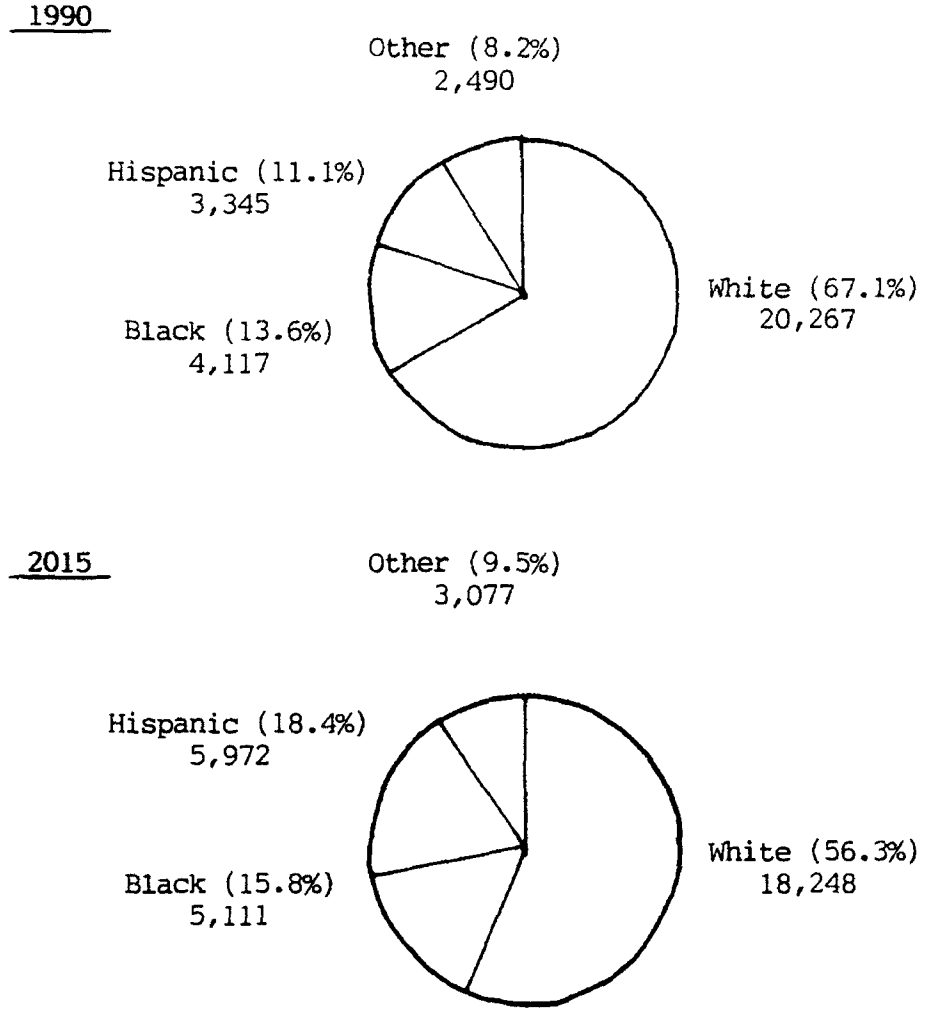

Figure 2: Population of 18-25 Year Olds by Ethnic Group (in thousands)

Region	2005	2015
Northeast	783,000	943,000
Southeast	446,000	562,000
Midwest	313,000	364,000
Southwest	1,207,000	1,523,000
West	1,999,000	2,580,000

Figure 3: Hispanic Population of 18-25 Year Olds
By Army Recruinment Regions

had a problem with acceptance of minorities, and this trend is expected to continue.

In the United States, the West is the fastest growing region, followed by the Southeast and the Southwest. By 2015, the West and the South will be the most populous regions in the United States, and California will remain the most populous state for two reasons. First, immigrants usually prefer warmer regions similar to the climates they left, and second, many people move to warmer regions after they retire. Most Hispanics immigrate to the West or the Southwest regions, and most Asians immigrate to the West or the Northeast regions. Large metropolitan cities are becoming more populous than in the past. Statistics estimate that more than half the nations population will reside in 39 large metropolitan areas.

THE ECONOMY

Predictions for the future economy are difficult to make. Most of the economic success depends on how it adapts to the globalized economy. The ideal world economy will be one that benefits all, and if the United States can become a bigger and more powerful part of the world economy, it will be a more successful nation, along with a more stable economy.

The economy is divided into manufacturing and service sectors. The manufacturing

sector includes plant production of tangible parts, mining, and construction. The service sector includes a wider variety of activities such as sales, communications, equipment servicing, finance, transportation, information supply, food services, and education. In the manufacturing sector, the Asian and European competitors have had success, while the United States manufacturing has declined. As a result of the struggling manufacturing sector, the service sector will rise. There could be up to 90% of the work force in the service sector in the year 2000. The progress of the service sector will have the largest impact on the military. The outcome will affect the amount of funding given to military projects.

As companies begin to cut back on employees, many of the middle management people will be the first to go. Many people feel that there are better results when there are fewer levels through which the information is passed. This will leave these people unemployed, or with a job that does not utilize his/her total capabilities. As a result of the decrease number of managers, managers of the future will have to have a variety of skills in leadership, market trends, and computer knowledge.

Small and large companies will grow more rapidly than middle sized companies which was also the result in the 80's. Many companies will divide themselves into smaller networks throughout the country, which will ultimately save energy and materials. However, accurate communication among the separate divisions could become a problem.

In the past, a large percentage of the nations budget went to the military. However, as the Cold War comes to an end, this could change. The Soviet Union does not pose as great a threat to the United States, and another world war is unlikely. Because of these situations, many people feel that money given to the military should be used for the economy or to help cut the budget deficit. However, the technology used in Desert Storm was such a success that this may give the government more incentive to continue large military funding.

The single most important concept of the future economy will probably be how it adapts to the globalized economy. The world is becoming more connected in political, economic, and manufacturing areas, and the ability of the United States to become a part of these areas will determine its success. The United States will have to go through many changes in the next 25 years, and will have to adapt to many new global situations.

RESOURCES

The most important resources to human beings are food, water,and medicine. The United States has an ample amount of these resources. The United States produces much more food than it consumes, and this trend will likely continue. The United States also has an abundance of key raw minerals such as sulfur, potash, and phosphate rock.

The military accounts for 80% of the government's energy consumption. Three of the most critical materials to the military and the industrial society are steel, aluminum, and refined petroleum. In the 50's, the United States produced a large percentage of these materials, but these percentages have dropped drastically (See Figure 4) and may cause problems.

	1975	1990	2015
Steel	17%	10%	4%
Aluminum	30%	21%	9%
Refined Petroleum	23%	15%	7%

Figure 4: Percentage of U.S. Production of Selected Materials Compared to the Rest of the World

The United States depends strongly on energy sources such as oil, natural gas, and uranium. Oil is the primary source of energy for the United States and is a major importer. The importance of oil to the American society is not expected to decline (See Figure 5). The United States gets most of its oil from Middle Eastern countries, which can be risky because some of these countries are economically unstable, and difficult to work with (for example, Iraq). One way to help the energy crisis is to conserve and recycle. The military is expected to play a major role in conserving and recycling not only resources from the United States, but also helping other countries conserve their own resources.

Natural gas is one resource that is not as critical for the armed forces, but is still needed

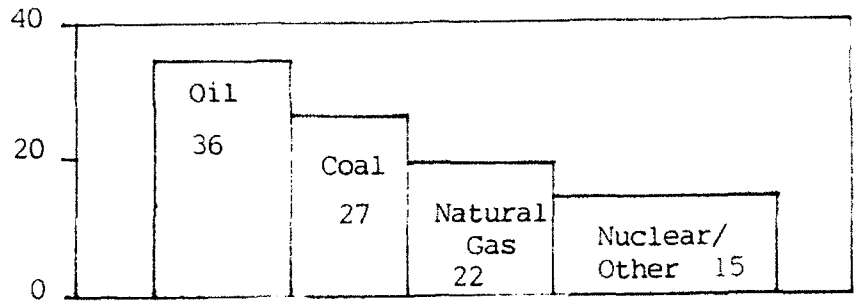

Figure 5: Projected percentage of U.S. Energy Sources

in society. Although the United States is the largest importer of natural gas, gas production is beginning to increase. The United States will still have to continue importing, but probably from Canada who is a more reliable source. Coal is one of the fossil fuels in which the United States has an ample amount. Although ample, coal does not outweigh the money spent importing oil and natural gas.

The United States has stockpiled fuel and nonfuel mineral to be saved for times of crisis. In order to be stockpiled, materials must not be found or produced in the United States in sufficient quantity, and must be required to supply military, industrial, and essential civilian needs in a national defense emergency. Minerals such as chromium, titanium, cobalt, and the platinum group metals are stockpiled because they are essential for both defense and the high-technological industry.

Use of rubber, steel, lead, and aluminum will probably decline in high technology manufacturing. Upcoming technology might use rare earth metals. The United States was the leading producer of rare earth metals in 1990, and also a major exporter. Electronic metals such as silicon, cadmium, gallium, germanium, and tantalum are important to technology and the armed forces and are also stockpiled.

EDUCATION

The quality of American education is declining, and as a result, the United States is not as competitive as other nations. Reforms need to be put into action, but any reform will take years to actually see the results - well into the 21st century. Many people believe that a national

curriculum, which would stress mathematics and science, would help the United States compete in the rapidly advancing technological world. Another type of reform for the future may be school choice. In this program, people will choose which school they want to attend because of the schools reputation and not because of what district they live in. This will provide competition among the schools for students, and ultimately the schools with the best reputations will succeed. The other schools will have to improve or they will be closed down.

The number of minorities is growing rapidly, and by 2015 they will make up two-thirds of the population in the public school system. Schools will need to set up programs to adjust to the number of diverse cultures. Many of these children will be disadvantaged children with one or more of the following indicators: minority racial/ethnic group identity, living in a poverty household, living in a single parent family, having a poorly educated mother (usually the head of the household), or having a non-English language background.

Many people believe that a child's family background is the best way to determine academic success. The growing number of disadvantaged children in society today could be a major reason why there is a decline in classroom achievement. In order to improve this, parents need to play a major role in their children's education, and emphasize to them the importance of education.

Many people feel that one reason the education system is lacking is because of the length of the school day and the school year. Other nations that outperform the United States have both a longer school day, and a longer school year. This type of reform may likely go into effect to some extent in the future.

The impact of a poor education system has on the military is debatable. Some say the pool of applicants that the military has to choose from may be less literate than those of the past. If this is the case, then the military will need to teach the skills that the students are lacking in order to maintain the military's prestigious reputation. Another side feels that because of economic problems throughout the country, many more students will look to the military as a way to get themselves on a good track for a career. Therefore, the military will still have a large field of applicants from which to choose.

SOCIETY

The American society as a whole will most likely suffer in the next 25 years. The standard

of living will decrease for the majority of the work force, and most people will not be as well off as their parents were. Some feel that the United States is going through a crisis period, and that the 1990's must be a decade of change or the next decade will be disastrous.

The society of the future will have less of the traditional family, which, as it is now, only makes up one-fourth of all American households. The two major types of households today, which will continue to grow rapidly are the single-parent households, which are usually headed by women; and the "blended" family, which consists of children of a previous marriage along with the children of the new marriage. Some of these households are very unstable and could affect the children in a negative way. The military could also be affected by unstable households. Those children from unstable households may reject the authority and discipline enforced in the military while others may welcome it. There will also be a larger percentage of active duty soldiers who may be the head of a single-parent household. This could cause problems if the soldier is sent away on duty. The military will have to be prepared for these dilemmas.

The population is aging, and in the next century, the older will outnumber the young. This is a result of the aging Baby Boom generation, and the advance in medical technology that has lengthened expected lifetime. As the Baby Boomers age, the American society will need to put more emphasis on meeting the health care needs of this generation. This will be difficult. Medical care will continue to become more expensive. There will be fewer workers per retiree, and therefore less money for social security. In order to support the elderly health care, a whole new system may need to be devised.

There are some very negative aspects of the American society, and much needs to be done to improve them. Some of these problems are the crime and violence in many large cities, which leads to the largest prison population in the world. In addition, there are problems with drug abuse, and teen-age pregnancies. Many people believe that these problems can be resolved, but in order to have any impact they need to have the support of the public.

TECHNOLOGY

Technology is a combination of four related concepts: hardware, process, system, and environment. All four concepts must be involved in order for technology to be effective.. Technology changes at an extremely rapid pace, and will continue to advance in the future.

However, the rate of future advances is unsure, but not all technologies advance at the same rate. There are "mature" technologies which have already advanced to a certain extent and will probably not go through as much change as some newer technologies. The newer technologies will change at a rapid pace until they have advanced enough to be considered a "mature" technology.

Scientific research is the first stage of technology. Ultimately, research will lead to a successful products, which will in turn aid the research for newer technologies. The newer technologies, throughout the years, have been very practical which has allowed a wide variety of people to use them, and has benefitted the whole American society. For technology to be as successful as in the past, it needs to continue to be useful to common people.

Computers have been the most rapidly advancing technology, and will continue to advance well into the 21st century. The most important component of computers is the software, and the United States leads the rest of the world in software development. However, as hardware becomes more powerful and less expensive, the software must not be overlooked. It must develop at the same rate as the hardware in order to be successful; and the United States must continue to support this software development in order to remain the world leader.

Technology will continue to be the single most important concept for the military in the future. Not only has the military benefitted, but they have been a major participant in its development. This development was proven in Desert Storm where they used many new technologies that resulted in very few casualties. Because of this success, the political support for technological experiments will most likely continue.

Many believe that there are limits to technology. One physical limit is believed to be the speed of light because it is the fastest speed at which anything can occur including computer processing. However, further advances in technology could change things so that limits that seem insurmountable today could be overcome in the future. Currently, companies are working on a type of processing called parallel processing that could someday exceed the speed of light.

Other limits that could drastically affect technological advancements in the United States are the low number of properly trained people and the declined enrollment in technical fields. Educational technology has not developed as rapidly as expected mostly because of the cost factor. As a result, the United States' ability to compete with the rest of the world in advancing technology is declining because of fewer people with sufficient technological knowledge or training.

Much of the technological success from the past came from immigrants who came to

study in U.S. schools and who stayed here to work. Many of the original countries are now offering these same people higher paying jobs to return to their homeland. If the United States cannot offer the same amount of pay, there may be problems of having to rely on foreign nations for technological purposes. Along with these researchers and scientists, many industries are also moving their operations abroad. These industries are more efficient and less expensive abroad resulting in purchases abroad instead of trying to produce our own. Losing critical industries to companies abroad cannot be done without great risks to the United States..

MILITARY SCIENCE/GEOPOLITICS AND THREAT

Traditionally, the United States has always played a key role in keeping peace and stability throughout the world. In the years to come, the United States is expected to continue this and insure that no country acquires too much world power. China is one nation that is expected to gain power, and this could be a cause for concern for the United States and its allies. The Soviet Union has always been a major threat to the United States, but this is expected to change. Internal problems have caused the Soviet Union to weaken in many areas including technology, and although their threat to the United States has decreased, it is not totally gone.

Other world threats are arising that could affect the United States and the rest of the world. A large number of smaller countries are acquiring nuclear weapons which makes them as much of a superpower as the United States. This could become as big a threat to the United States as the Soviet Union was in the past. As a result of increased nuclear weapons throughout the world, the United States may not want to intervene in small conflicts, like in Desert Storm, because of the possibility of this small conflict becoming a nuclear war. The U.S. policy on nuclear attack has been deterrence, or restraint, and this will continue to be a top priority. However, the manufacturing of nuclear weapons will continue in order for the United States to defend itself against nuclear attack.

The military of the future will be smaller but more professional. They will need to possess a wide variety of capabilities and be qualified to excel in all aspects of the military. Recruiting for the military will mean choosing the most highly qualified individuals regardless of race or sex. The reduction of military personnel will continue well into the next century. By 2015, there could be a reduction of one-third or even one-half of today's force.

Technology will continue to change the way a war is fought. Robots will be used to

replace man in places that are too dangerous for humans. The battlefield of the future could be completely computerized. Technology may have advanced to the point where weapons will be able to locate and strike a target, then report the results. Another high-tech system that could be developed is one that would "shield" the United States against nuclear weapons. However, there are opposing views on whether this system will actually be effective. Space technology will also advance in the future and will most likely serve as a surveillance method to detect regional disturbances.

The end of the Cold War has caused a disappearance of the bi-polar world. The United States and the Soviet Union will remain superpowers, but not to the extent that they were in the past. This allows European countries and Japan to emerge as superpowers like the United States. Many of these countries excel in different areas which benefit themselves and the rest of the world. Countries are becoming more and more dependent on each other in many areas such as the economy, resources, and technology. Further cooperation among all countries will be more important for future success and global peace..

ANALYSES OF VARIOUS SAMPLES FOR THE PRESENCE OF METALS

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Final Report for:

Air Force Office of Scientific Research

Armstrong Laboratory

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ANALYSES OF VARIOUS METALS FOR THE PRESENCE OF METALS

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ABSTRACT

The main function of the Metals Section of the Armstrong Laboratory is to provide support for bases worldwide in the analysis of environmental and occupational samples for metal content. These samples include, but are not limited to, drinking water, wastewater, soils, sludges, biologicals, and air samples. The section analyzes an average of 10,000 samples per year with the average of four or five different analyses. The sample load is almost evenly split between occupational and environmental samples. Analysis of the sample is accomplished by using several varieties of spectroscopic instruments including Inductively Coupled Plasma (ICP), Flame Atomic Absorption (FAA), Graphite Furnace Atomic Absorption (GFAA), and hydride generator for the analysis of mercury. This section also utilizes robotics in the preparation of samples for mercury analysis and in microwave digestion of samples.

ANALYSES OF VARIOUS SAMPLES FOR THE PRESENCE OF METALS

Mara L. Klompen

INTRODUCTION

The Armstong Laboratory Metals Section is an EPA compliance laboratory. The section must maintain certification through several national programs including EPA, NIOSH, OSHA, and the College of American Pathologists (CAP), as well as environmental certification programs from a number of states who run their own programs. The section does EPA compliance analyses which means that it helps bases comply with EPA guidelines by identifying problem areas through the analysis of drinking water, wastewater, soils, sludges, and biologicals. It also does air analysis that is monitored by NIOSH and OSHA. The program is quality controlled by both EPA and NIOSH as the section performs analysis of samples from both of these agencies. Also, the CAP monitors the analysis of the biological samples being tested for lead. In addition the section is also monitored by individual state agencies, some of which have stricter guidelines than EPA.

The Metals Section has also been involved in many special project. One such project was the analysis of the blood of Prisoners of War held captive in Iraq. Analysis of make-up manufactured in the Middle East was also done. The make-up was identified by a study done in cooperation with a national university as possibly having hazardous levels of lead. The

Metals section was also the main contributor to the Lead Assessment Program. This program identifies and monitors drinking water for lead contamination at bases worldwide. Soap samples are also analyzed for boron. The most recent project done was an analysis for lead in paint. Children at a local Air Force Base were suspected of having lead poisoning.

METHODOLOGY

In order to be EPA certified the Metals Section must use EPA methods to perform these analyses. NIOSH also requires approved methods. Some examples of EPA methods that the section uses are: (1) 200 series methods for both potable and non-potable water, (2) SW846 methods for wastewater and solid materials including paint, wipes, soil, etc., (3) a specific method, 239.2 which is used for lead analysis through a Graphite Furnase Atomic Absorption Spectrophotometer, and (4) also a specific method, SW846 method 6010 is used for analysis on an Inductively Coupled Plasma Emission Spectrophotometer. NIOSH methods are used for air and biological analysis. One specific method is NIOSH 8003. It is used on the analysis of lead in blood.

APPARATUS

All of the analyses are processed using advanced electronic equipment. This equipment is operated by the principle of

detection of light absorption of light emmission. The range of equipment consists of three general categories of spectrophotometers: (1) Flame Atomic Absorption, (2) Graphite Furnace Atomic Absorption and (3) Inductively Coupled Plasma.

The Flame Atomic Absorption Spectrophotometer (FAA) introduces a liquid sample into an air-acetylene flame. A hollow cathode lamp containing the metal of interest is lit and gives off light at a wavelength characteristic of that metal. If the sample contains that metal, it absorbs the light at that wavelength, and is compared to a set of standards to obtain a concentration in micrograms per liter. The Graphite Furnace Atomic Absorption Spectrophotometer (GFAA) is the same principle, but only microliter amounts of the sample are used, and the sample is subjected to programmed heating and is much more sensitive than the FAA.

The Inductively Coupled Plasma Emission Spectrophotomer (ICP) works on the principle of emission of light. A sample absorbs energy in the form of heat and releases the energy in the form of light. The light emitted is at a wavelength characteristic of that metal. The amount of light emitted is compared to the standards.

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STUDY OF RADIATION AND ENVIRONMENTAL MONITORING PROCEDURES

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Department of Radioanalytical Services

Final Report for:
AFOSR Summer Research Program
Armstrong Laboratory

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Brooks Air Force Base, San Antonio, Tx.

August 1992

STUDY OF RADIATION AND ENVIRONMENTAL MONITORING PROCEDURES

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Abstract

The preparation and analysis of environmental potable and non-potable water samples for the presence of radiation was studied. To prepare the water samples, they are treated with 8N nitric acid and sit for at least 18 hours. They are dehydrated under infrared lamps and a sediment of 200ml of sample is taken and placed in a planchet. The sediment is analyzed for emitted alpha particles in the MICRAD. If beta particles or gamma rays are thought to be emitted, the sample is also analyzed for these.

STUDY OF RADIATION AND ENVIRONMENTAL MONITORING PROCEDURES

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INTRODUCTION

Radiation is a chief form of energy that can come in three forms. Two of these forms are cosmic and nuclear radiation. Cosmic radiation constantly surrounds us. It originates from supernovae (exploding stars), pulsars (extremely dense stars), and is given off by the sun during solar flares (eruptions). These give off cosmic ray particles which include electrons, protons, helium and hydrogen nuclei, and nuclei of heavier elements such as carbon and oxygen.

Nuclear radiation comes from radioactive atoms which emit alpha particles , beta particles , and gamma rays. Nuclear radiation occurs naturally in the rocks and minerals of the earth's crust, but can also be made artificially. Artificial nuclear radiation, like that produced in nuclear reactors, occurs by the bombardment of atoms with high energy protons, neutrons, and other accelerated particles.

Like other things, radiation has its pros and cons. Primarily, radiation from the sun is essential for life on Earth. Sunlight provides warmth, and makes vegetation thrive, which provides food for animals and people. In everyday life, we use radiation in communications, in industry, in the medical field, and in research.

Even though radiation can be beneficial to us, it can also be very harmful. As many people know, an excessive amount of exposure to the sun can cause sunburn & skin cancer. This isn't the only harm radiation can cause, however. Radioactive emissions are capable of penetrating biological tissue and breaking molecules within cells.

High doses of radioactive emissions may prevent or mutate cell division. This is good if they are focused on cancerous tumors to destroy them. However, acute exposure to radioactive emissions can prevent the normal replacement or repair of blood, skin, and other tissues. This results in radiation sickness, which may lead to death within a few days or months dependent level of exposure. Very high doses of radiation may totally destroy cells. This results in immediate death.

In low doses, radiation may damage DNA molecules. Cells with mutated DNA may begin dividing and growing out of control, causing tumors or cancers. If an egg or sperm is involved, the radiation may lead to birth defects.

The subject of nuclear power plants strikes fear in most people. During normal operation of these plants, however, radiation levels are very low. Unstable isotopes in these plants are radioactive, but as they decay in a radioactive chain, the radiation level decreases. Nevertheless most people's concerns lie in the disposal of radioactive wastes and accidents in the power plants.

Accidents in nuclear power plants can happen. If a fallout occurs, the area around the plant, and possibly beyond, will be contaminated. These accidents usually occur because of carelessness or lack of knowledge.

As for the disposal of radioactive wastes, those that require short-term containment are stored in deep swimming pool-like tanks on nuclear power plant sites. The water in the tanks dissipates the waste heat, and acts as a shield for radiation. However, it's a problem containing long-lived radioactive wastes.

For the time being, long-lived wastes are being kept in short-term containment. It has been found that when short-term containment units are used longer than their intended lifetimes, they leak and contaminate the soil and water. This poses a threat to the future of our environment.

On the military bases around the world, water sampling for radiation is performed on a regular basis. This is to test the suitability of drinking water. In the Armstrong Laboratory radioanalytical department, many water samples are received. These are mainly tested for alpha particles, but can also be tested for beta, gamma, and other analyses that are requested. During our stay here, we learned how to prepare and analyze potable water samples, in accordance with Air Force Regulation 161-44, which is the Standard Drinking Water Act, governed by the Occupational Safety and Health Act.

METHODOLOGY

In order to prepare the drinking water samples, which get analyzed mainly for alpha emitters, they must first be logged-in, receive a sample number, and be given a working card where all the information about the sample and its results will appear. After this is done, the samples must be preserved with 8N nitric acid, and be left to stand for 18-24 hours.

Then water is transferred beaker. The beaker is set under infrared lamps, and the water is evaporated.

After the water has evaporated, a residue remains and a solution of distilled water and .1N nitric acid is added to this residue. The beaker is then policed, and the residue is transferred to a weighed planchet, and set to dry under the infrared lamps.

Then, because the heat lamps do not totally dry the sample solution, the planchet is flamed. Once flamed, the total mass is determined by weighing on a Mettler Balance. If the sample mass is greater than 200mg, the procedure must be repeated with a smaller sample volume. After all the water samples are ready, they are placed in a dessicator and taken to counting.

Before the samples are counted for alphas, however, the lab technicians must make certain that the equipment is working properly. To test the MICRAD, the alpha gas proportional detector, quality assurance and background should be run. The quality assurance sources have a known amount of radiation, and are used as the controls. These take two minutes to run. The background is used to detect the cosmic radiation, which is the amount of radiation already present without the samples. This takes 100 minutes to run. Other things to check for are that the bubble rates, which indicate the gas flow rate, are not too slow or fast, that the detectors are clean, and that the P10 gas (an argon/methane mixture) is on and has no leaks.

Once the detectors have been checked, and have been found acceptable, the samples are placed in the MICRAD, which has ten chambers.(When handling samples, gloves should always be worn for protection.) After this has been done, the numbers of the detectors are

written on the corresponding sample cards. To begin a 100-minute alpha detection count on the samples, the knobs on the MICRAD are turned to raise the planchets into the counting chamber. This allows the samples to be counted.

Once the testing has been concluded, the raw counts are recorded on the sample cards. Afterwards, analyses on the samples have to be calculated on a separate computer. In order to calculate and analyze the samples, the computer needs to know the sample numbers, the number of background counts, the length of time for which the background was counted, the alpha counts, the length of time for which the samples were counted, and the weight and volume of the samples.

As soon as the samples are analyzed, the results are printed on labels and placed on the sample cards. Sometimes samples need other sorts of analyses. If so, the samples need to be saved, and placed in other detectors. If the samples need no further analyses, they are placed in storage and, eventually, properly disposed of.

CONCLUSION

In conclusion, we have learned many new things. We were welcomed into the world of radiation with gloved arms. We now know what radiation is, the various types of radiation, and the methods of detection. We had the opportunity to work on several types of electronical radiation detection equipment, and a variety of computers with many diverse analysis programs. We learned almost all the dangers associated with radiation and a few of the benefits. We were bombarded with theory and laboratory safety practices. All in all, it was a very educational experience and we can honestly say we have "glowed" with the best of them.

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A STUDY OF THE EFFECTS OF ONE NIGHT'S SLEEP LOSS ON PHYSIOLOGICAL DATA

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Final Report for:
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Armstrong Laboratory

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A STUDY OF THE EFFECTS OF ONE NIGHT'S SLEEP LOSS ON PHYSIOLOGICAL DATA

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Abstract

Physiological data were collected during a sleep deprivation experiment in order to discover physiological changes produced in humans by lack of sleep. Eleven male subjects were given a series of tasks to perform on several days. On each of these days, physiological data were collected and stored on the Psychophysiological Assessment Test System (PATS). Analysis of this data, also performed on the PATS, indicates a decrease in heart rate with an increase in heart rate variability after the period of sleep loss. Although the eyeblink analysis is not quite as clear-cut as that of the heart rate, after 24 hours' loss of sleep the subjects tended to blink more often and for longer durations. The electroencephalographic (EEG) data have yet to be analyzed. Knowledge of physiological reactions to this stressor might help in the anticipation and reduction of negative effects to sleep loss.

A STUDY OF THE EFFECTS OF ONE NIGHT'S SLEEP LOSS ON PHYSIOLOGICAL DATA

Lisa E. Dillhoff

INTRODUCTION

New technology is constantly developing more advanced machinery and techniques to improve human performance, but the capacity and limitations of the human body need to be taken into account. Physiological data collected during a sleep deprivation experiment are being analyzed in hopes of finding significant changes in electrooculographic (EOG), electrocardiographic (ECG), and electroencephalographic (EEG) data. Two prime points of interest are the heart rate and eyeblinks. Such analysis has been performed to detect the frequency of R-waves and the variability of the heart rate. Eyeblink frequency, duration, and amplitudes are also being taken into account. Many stressors such as loss of sleep can inhibit a person's performance. These experimental results may help in determining to what extent a body can function and perform adequately with significant sleep loss.

METHODOLOGY

This experiment was conducted early in 1991 as a thesis proposal by Michael D. Gravelle to measure actual performance data. While this experiment was being conducted, physiological data were collected as well. Most often, in experiments of this nature, the degree of workload or the environment in which the test is administered is changed. In this study, however, the condition of the subject himself was altered. The Standardized Tests for Research with Environmental Stressors (STRES) Battery was chosen, providing a wide range of mentally diverse tasks for the subjects to perform. The results of these tasks vary in performance and physiological data outputs. Physiological data were continuously collected during the testing periods on the Psychophysiological Assessment Test System (PATS) from each of the

subjects. The subjects were run two at a time, one on each of two computers. The fourteen tasks administered, which comprise the STRES Battery, are the following:

* Reaction Time Tasks (6)
* Mathematical Processing Task (1)
* Memory Search Tasks (2)
* Spatial Processing Task (1)
* Unstable Tracking Task (1)
* Grammatical Processing Task (1)
* Dual-Tasks (2)

While the subjects were performing the 14 tasks, physiological data were being collected. These include one EOG, one ECG, and three EEG channels. Electrodes were placed on sites of the head and chest to detect electrical activity from the brain, eye, and heart. The electrical impulses detected by the electrodes were then transferred to the PATS, digitized, and recorded. (The PATS was calibrated and data recorded at 1000 Hz sampling rate which provided sufficient, manageable amounts of data for analysis.) The vast amounts of data were then stored on disk to be analyzed at a later date.

Analysis of large amounts of data has been made significantly less difficult due to the capabilities of the PATS. The PATS was designed with the analysis of physiological data in mind. Before trying to interpret the eyeblink data for one subject for a specific task on a certain day, the large data file containing the information must be "broken down." The PATS makes this process possible. Because two subjects were run at the same time, their data were collected simultaneously. Five channels of data for each subject were recorded on PATS. Sixteen data files were collected for each pair of subjects every day of the test. The data files contain physiological data for each subject for each test in the STRES battery, in addition to a pre- and a post-baseline recording for each day. By use of the PATS, a data file consisting of 10 channels, five for each subject, can be parceled into useful segments. Thus, any or all of the 10 channels may be selected for further analysis.

When heart rate analysis is desired, the ECG channel is selected and viewed. To measure a subject's heart rate and heart rate variability, R-waves are detected and

analyzed. (Heart rate variability is determined by the intervals between beats of the heart.) An R-wave, simply described, is a heart beat. When ECG data are recorded, a continuous line of digitized electrical impulses flows across the screen. This line's amplitude changes with the heart's beating. Prior to an actual heart beat, the heart gives off a small pulsation. A large wave then occurs (the heart beat), and another small pulsation follows. The points at the positive- and negative-going peaks of these waves are uniformly lettered P, Q, R, S, and T, as shown in Figure 1. The point at the peak of the actual heart beat is lettered "R," thus the name R-wave.

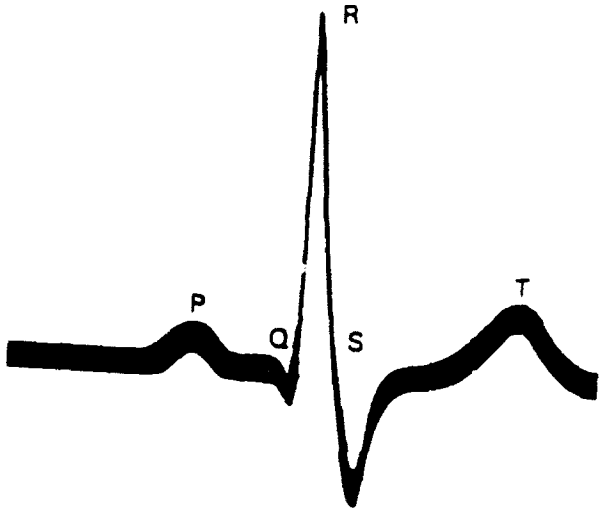

Figure 1 *An R-wave is named as such, because the variable "R" is used to identify the heart beat's positive-going peak of greatest amplitude. This peak is recognized as the actual heart beat. It is standard procedure to label the peaks and troughs of a characteristic heart beat with the letters P, Q, R, S, and T.*

Before the PATS can detect R-waves, it must be instructed as to what an R-wave is. Parameters are set, specifying the minimum and maximum interbeat interval, cardiac amplitude, and minimum slope (in 20 milliseconds) of an R-wave. The PATS then detects and marks the waves in the file that fit the defined parameters. The parameter specifications guarantee that the small pulses both before and after the actual heart beat will not be detected as R-waves. The parameters can be changed, since individuals' physiological performance data are unique. Heart rate and R-wave amplitude are fairly regular from person to person. Therefore similar chosen parameters can be used, for the most part, for all subjects. Statistics are then made

available through the Porges-Bohrer Filter pertaining to the heart beats per minute, interbeat intervals (IBIs), band variance, and other relevant information.

Eyeblinks are not as uniform as heart beats and require somewhat more time-consuming procedures for proper analysis. However, the concept is the same and similar guidelines are followed. In the case of eyeblinks, the EOG channel of data is selected from the data file to be analyzed. Eyeblink data vary with regard to the individual subject, the visual demand of the task, and the conditions under which the task is administered. The data from the unstable tracking task and the two dual tasks show a great repression of blinks due to the high visual demand. Blinks also tend to be of lesser duration. (Subjects blink more quickly to avoid "missing" anything.) Because the EOG data are so irregular, parameters often need to be adjusted. The PATS is instructed to place a red marker through any movement which fits the given parameters. Any movement in the EOG channel whose amplitude, duration, and slope are within the specified range is considered a blink and receives a blink marker. However, these "blinks" need to be edited due to the diversity of eyeblink data. Large or small eye movements and certain amounts of "noise" from data collection occasionally fit the set parameters and are given markers. The trained eye recognizes that those are not blinks. Improperly placed red markers are then removed and any blinks which weren't detected are marked as such. (Again because of the lack of uniformity of eyeblink data, certain blinks are undetected. Blinks can fall short of the defined minimum amplitude or duration and be "overlooked" by the computer. Manual editing can relieve this problem.) Once the data have been sufficiently analyzed and corrected, the information containing statistics on the data (i.e. eyeblink amplitudes, durations, and events per minute) is stored.

It isn't enough to have all of the numbers and statistics stored on disk; it must be determined if the values calculated are significant. A special program was designed for this analysis to provide easy access to desired information. By using this program, any or all files pertaining to a particular statistic may be drawn up and data can be grouped by the press of a button. For example, to look at the average heart rate for all subjects during a reaction time task, the files containing the relevant information are selected. The program is then set for heart rate analysis. The numbers stored in the Porges-Bohrer Filter files (relevant to heart rate) are copied and stored in a new file.

At this point in time, analysis of ECG and EOG data for four of the eleven

subjects has been completed. The heart rate, heart rate variability, eyeblink amplitude, blink duration, and blink rate data for these four subjects have been stored, using the program mentioned above. By use of Microsoft Excel spreadsheets, this information has been placed into columns and rows, to provide easier interpretation of the data. Five columns have been created, each containing numbers from one day's data collection. Day one's data are on the far left; day five's on the far right. Four rows have been completed as of yet, each containing one subject's data. Data pertaining to the remaining seven subjects can then be added once they have been analyzed. These procedures have been used for all fourteen tasks and both baseline recordings for heart rate, heart rate variability, eyeblink amplitude, blink rate, and blink duration. By use of Microsoft Excel, graphs have been plotted as well. The spreadsheet information was transferred to a chart, given the desired characteristics, and printed for viewing. Once the charts were completed, it was possible to look for significant changes and patterns in the various physiological data.

PROCEDURE

This sleep deprivation experiment was designed as a five day study to record the effects of sleep loss on numerous subjects. Eleven male subjects, all students from Wright State University, were tested while performance and physiological data were being collected. A practice day was set aside to familiarize the subjects with the lab and the tasks. The first testing day with data recordings was a Thursday, after the subjects had had an adequate night's sleep. Friday was the next day of data collection, also with the subjects well rested. These two testing days provided baselines, to which the sleep-deprived day's data could be compared. After Friday's testing, the subjects were kept awake for 24 hours. During this time, they were permitted to read, listen to music, play games, watch television, etc. Saturday, after 24 hours' sleep deprivation, the tasks were administered a third time. Data were collected on Sunday and Monday to check recovery time.

Five channels of data were recorded for each subject - one EOG, one ECG, and three EEGs. Electrodes were placed on specific areas of the head and chest in order to record the proper electrical impulses. When detecting EOG data, two

electrodes were placed on the face, one above and one below the eye. These detected electrical activity that occurred near the eye. The eyelid gives off a discrete electrical charge when it closes over the eye. These charges were detected by the electrodes, digitized, and recorded on the PATS. The ECG data were recorded in much the same way. Two electrodes were placed across the chest, one on the sternum and another on the abdominal area, to record the heart's electrical impulses. Once again, the impulses were digitized and recorded on computer. The three EEG channels which were recorded are the central (Cz), parietal (Pz), and occipital (Oz). These pertain to particular areas of the brain where electrical activity occurs. The electrodes were then checked, to ensure proper electrical impulse detection, and noise was reduced to a sufficient level so as not to corrupt the collected data. The PATS was programmed to collect data at a sufficient sampling rate, and data collection began.

RESULTS

When the plotted heart rate, heart rate variability, eyeblink duration, blink amplitude, and blink rate graphs are viewed, some surprising information presents itself. The eyeblink results are somewhat inconclusive, but the heart-related data has a definite pattern. The charts for heart rate and heart rate variability show a fairly consistent "W" pattern (See Figure 2). Occasionally the fifth day's heart rate or heart rate variability drops below that of the fourth, but the pattern is still quite prominent. All points on all graphs represent the combined averages of the four subjects' data. The five points on each graph are the averages calculated for the five testing days. They are plotted in the order in which the data were collected. Thursday's data are on the far left, Friday's at the following point, Saturday's in the middle, and so forth. Each category (heart rate, heart rate variability, eyeblink duration, etc.) has 16 plotted graphs. These include a pre-baseline graph, a post-baseline graph, and one graph for each of the 14 tasks performed. A grand mean was plotted for each category, averaging the graphs of the 14 tasks. (The grand mean graphs do not include data from either of the baselines.) These graphs fairly accurately represent the patterns detected when the multiple graphs in each category are viewed.

As aforementioned, the heart rate data show surprising uniformity. In both heart rate and heart rate variability graphs, a "W" pattern is discernible. The heart rate was measured by interbeat intervals (IBIs). An IBI is the time that passes between beats of the heart. If the heart is placed under great strain (i.e. exercise), it tends to beat faster and the time between beats subsequently decreases. Therefore, the higher the heart rate, the lower the interbeat intervals (and vice versa). The heart rate graphs plotted

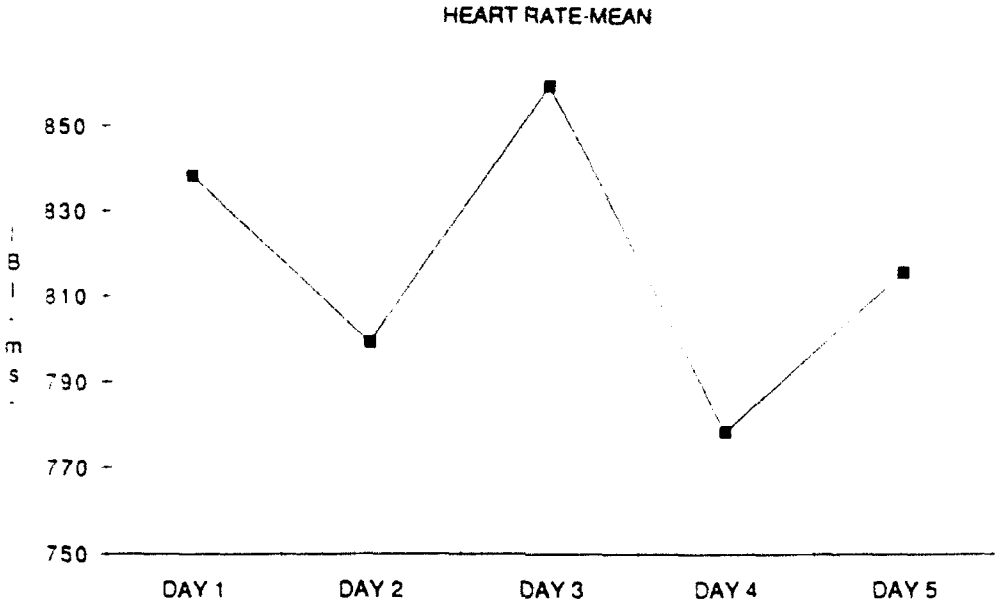

Figure 2 *This graph represents the grand mean for the heart rate graphs for the 14 tasks administered. A distinct "W" pattern is formed, revealing the differences in data during the five days of task administration. Notice the increase in interbeat intervals after 24 hours' sleep loss. This shows a definite slowing of the heart rate.*

show the variance in interbeat intervals. The decrease in IBIs from day one to day two shows that the heart beat faster on the second day of testing than on the first. The following increase in IBIs from days two to three shows a dramatic slowing of the heart rate after sleep loss. The average heart rate on the second day was 75.1 beats per minute, while Saturday's average, after the period of sleep loss, was only 69.8 beats per minute. Sunday's data show that the heart rate stabilized upon recovery, returning to a faster pace. The fifth and final day of testing resulted in a slower heart rate, on the average, and completed the "W" pattern.

Heart rate variability is closely related to the rhythm of the heart activity. Heart rate variability pertains to the small variations that occur between beats of the heart. When in a relaxed state, the heart beats somewhat irregularly. Respiration and other factors can affect the heart's rate and this can cause greater variability between beats as well. When the body is put under mental strain or forced to work harder, the heart tends to beat more regularly and with less variability. Thus, heart rate and heart rate variability go hand in hand. The heart rate variability graphs, like the heart rate (IBI) graphs, form a "W" pattern with consistency (See Figure 3). From the first to second

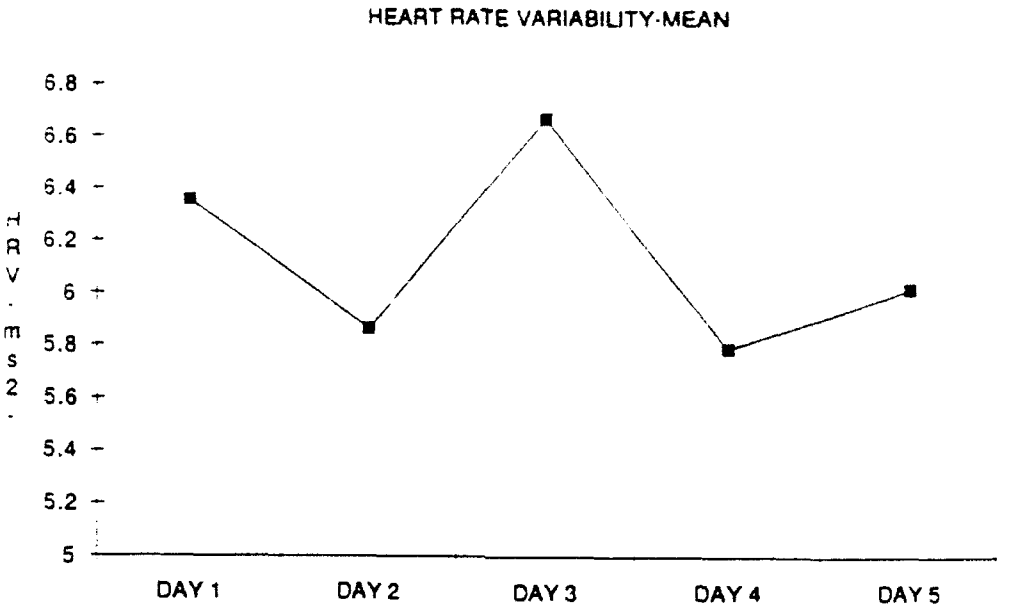

Figure 3 *This heart rate variability graph represents the grand mean for all 14 tasks, with a pattern nearly identical to that of the heart rate (IBIs). A "W" pattern is formed, with the peak at Saturday's plot point . The variability is noticeably effected by the period of sleep loss.*

testing days, the interbeat intervals during testing decreased. This represents an increase in heart rate. Because the heart beat more rapidly, the variability between beats decreased. In the same way, when the heart rate slowed after sleep deprivation the variability was effected and an increase in variability resulted. This pattern also continued in a "W" formation.

Eyeblink data results, as expected, are less concrete. The most uniform pattern

is found in the blink rate. Though not on the same scale, charts from most tasks tend to show an upward linear trend. The fifth day average frequently drops below that of the fourth, but a consistent upward slant from days one through four is apparent. When the 14 tasks' graphs were averaged, the grand mean affirmed this trend (Figure 4). Blink rate apparently is effected by familiarity with the testing and not the night of sleep loss. The blink amplitude graphs are extremely random, providing little foundation for further hypothesis. This was to be expected, as blink amplitude is not often a measure with conclusive results. The eyeblink duration pattern is not nearly as defined as that

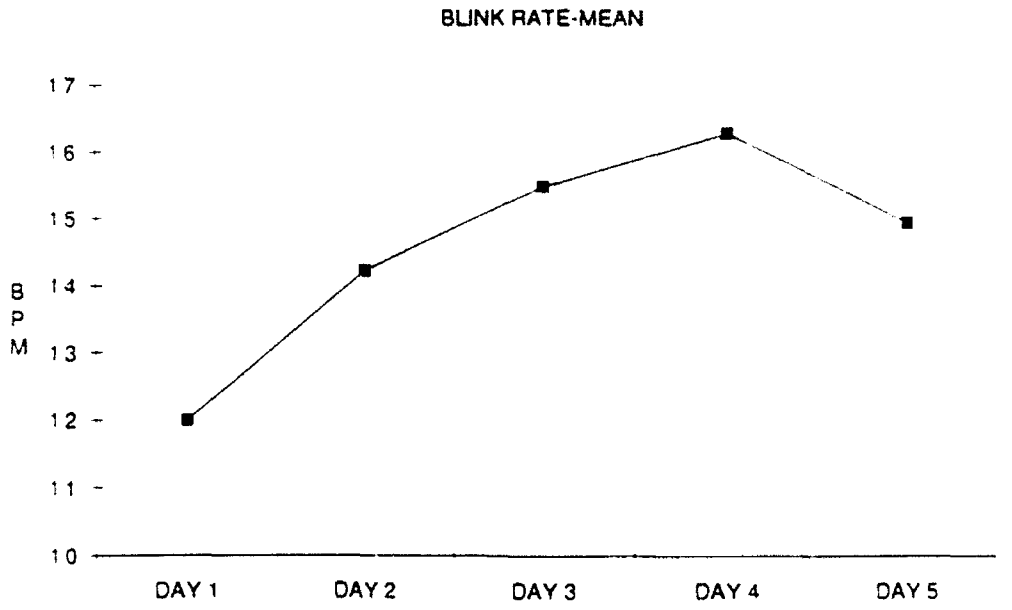

Figure 4 *The grand mean graph for blink rates is displayed above. This graph shows an upward linear trend, signifying an increased blink rate throughout the study. Though the fifth and final day produced a slight repression of blinks, as a whole, the trend is in the upward direction.*

of the heart rate or heart rate variability, but the peak of the graphs frequently appears after sleep loss (Figure 5). Though the heights of the first and last two days vary with relation to each other, 10 times out of 16 the peak of the graph appears on Saturday. The grand mean graph also shows Saturday as the day with longest blink durations. This is probably due to being tired after the one night's sleep loss.

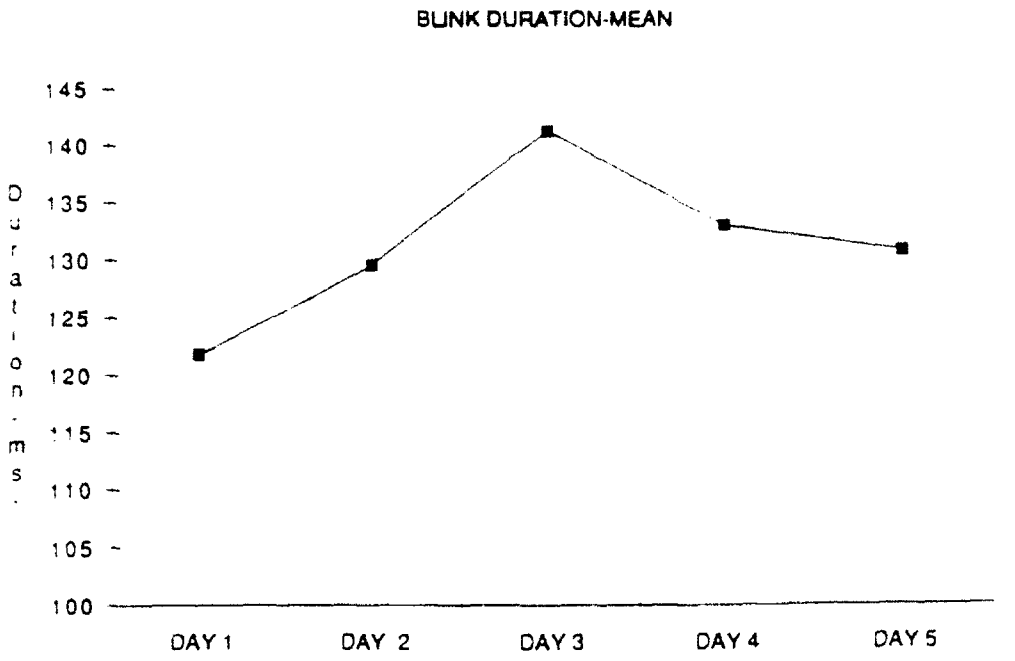

Figure 5 *This graph represents the grand mean of the 14 tasks' blink duration data. The blink durations of the four subjects increased, on the average, after sleep loss. After the subjects had a chance to recuperate, the blink duration decreased, resembling the data recorded before sleep deprivation.*

CONCLUSION

Bodies react to many kinds of stressors, including sleep loss (as demonstrated by this study). Both physiological and performance data were effected in this sleep deprivation experiment. The performance data is somewhat inconclusive, as not all data analysis has been completed. Physiological as well as performance data are an important means of measuring the amount of stress that can be placed on a person before his/her execution of duties is significantly hindered. This study has attempted to prove that variability is in fact produced in ECG, EOG, and EEG by 24 hours' sleep deprivation. From the analysis performed as of yet, heart rate and heart rate variability changes suggest that a recognizable, repetitive pattern occurs when subjects are deprived of 24 hours' sleep. Though eyeblink patterns are less discernible, there is reason to believe that, as a whole, people blink more often and for longer durations when they have been deprived of significant amounts of sleep. Efforts are forever being made to minimize errors during the performance of tasks, and to produce

maximum quality work. If problems such as sleep loss can be anticipated, and negative effects known in advance, precautions might be taken to avoid adverse reactions to the stressors. The results of this study may then provide a basis for knowledge of physiolcgical hindrances caused by sleep loss.

THE VELOCITY DEPENDENT VARIATIONS IN THE MAGNETIC AND ELECTRIC FIELDS OF A CHARGED PARTICLE MOVING AT A CONSTANT VELOCITY IN ONE DIMENSION

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PURPOSE

This research is meant to explore the relationship between the velocity of a non-accelerating charged particle and the strength of its magnetic and electric fields. It has the additional purpose of acting as the base for further research into the shape of the fields generated by the particles and, later still, exploration of the fields of accelerating charged particles.

HYPOTHESIS

The strength of the electric field will increase and the strength of the magnetic field will increase as the velocity of the particle increases. We conjecture this because we consider that the energy of the moving particle due to its motion will be transferred to the electromagnetic fields.

METHODS

To explore the relationship between a charged particle's velocity and the strength of its magnetic and electric fields, a computer program was needed that would simulate the system and generate the desired data. Introduction to the Theory of Relativity by Peter Gabriel Bergmann (page 140) contains a system of seven equations that describes the electric and magnetic fields of a charged particle moving one dimensionally. In these equations E_x is the X component (the X axis is important because it is the axis along which the particle moves) of the electric force on the

observing test charge, E_2 is the Y component of the electric force on the test charge, and E_3 is the Z component of the electric force on the test charge. Similarly, H_1 is the X component of the magnetic force on the test charge, H_2 is the Y component of the magnetic force on the test charge, and H_3 is the Z component of the magnetic force on the test charge. The equations for these component vectors are:

$$E_1 = e\frac{(X-VT)}{N}$$

$$E_2 = e\frac{Y}{N}$$

$$E_3 = e\frac{Z}{N}$$

$$H_1 = 0$$

$$H_2 = -\frac{V}{C}e\frac{Z}{N}$$

$$H_3 = +\frac{V}{C}e\frac{Y}{N}$$

$$N = \sqrt{1-\frac{V^2}{C^2}} * \left[\frac{(X-VT)^2}{1-\frac{V^2}{C^2}} + Y^2 + Z^2\right]^{\frac{3}{2}}$$

The X, Y, and Z in these equations are the locations of the observing test charge in the laboratory frame. The velocity and time measurements in these equations are laboratory frame measurements of the charged particle's movement.

Fortunately, a two dimensional picture of the electric and magnetic field changes can be built while only computing points in

one dimension. The equations for E_2 and the equation for E_3 are exactly the same except, of course, for the coordinate. These equations make it apparent that the electric field is symmetric around the X axis and therefore only plotting points on the Y axis will still give a full picture of the electric field. Similarly the equation for H_2 and the equation for H_3 are identical except for their accompanying sign. The argument still holds because a sign change is all that is required to translate the Y component (H_2) values onto Z component (H_3) values. In addition, if vector magnitudes are the measurements being used then the sign becomes unimportant because both equations become positive.

We have approached the above equations in two ways: mathematical manipulation and computation by digital computer. We have studied primarily the electric field magnitude. Define

$$\sum^2 = E_1^2 + E_2^2 + E_3^2$$

Then

$$\sum^2 = \frac{e^2 [(X-VT)^2 + Y^2 + Z^2]}{(1-V^2/C^2)[(X-VT)^2/(1-V^2/C^2) + Y^2 + Z^2]}$$

Let $D = (X - VT)^2$ so that D is the distance squared of the charged particle from the observer plane. Let $R = Y^2 + Z^2$ so that R is the distance squared of the observer from the charge particle trajectory. Define $\underline{a} = 1/(1 - V^2/C^2)$ so that $\underline{a}$ increases from the number 1 to infinity as V increases from zero to C. Then

$$\sum^2 = \frac{ae^2 [D+R]}{[aD+R]^3}$$

When R = 0

$$\sum^2 = \frac{e^2}{a^2 D^2} < \frac{e^2}{D^2}$$

so particle velocity decreases electric field strength from the static value (e^2/D^2) along the particle trajectory.

Since

$$\sum^2 = \frac{ae^2 D[1+(R/D)]}{D^3[a+(R/D)]^3}$$

when R/D >> a >> 1

$$\sum^2 \approx \frac{ae^2}{R^2} > \frac{e^2}{R^2}$$

so particle velocity increases the electric field strength over the static value when the observer is very much further from the trajectory than the particle is from the observer plane. However, when a>> R/D >> 1

$$\sum^2 \approx \frac{e^2 R}{a^2 D^3} < \frac{e^2}{R^2} \qquad \textit{for a large enough}$$

so for intermediate observer distances relative to particle distances, velocity can decrease E field strength from the static value.

Since

$$\sum^2 = \frac{ae^2 R[D/R+1]}{R^3[aD/R+1]^3}$$

when D/R >> 1,

$$\sum^2 \approx \frac{e^2}{a^2 D^2} < \frac{e^2}{D^2}$$

so particle velocity decreases electric field strength from the

static value when observer distance from the particle trajectory is much less than particle distance from the observer plane.

When aD/R >> 1

$$\sum^2 \approx \frac{e^2}{a^2 D^3}[R+D]$$

Thus, there are regions where electric field strength increases with increasing R but decreases with increasing D.

In summary, algebraic study suggests that electric field strength is driven away from the particle trajectory but is gathered at a distance off the trajectory but near the moving particle.

I have written computer programs to address these algebraic findings. Program #1 in Appendix #1 plots E_1, E_2 and E_3, H_1, H_2 and H_3 as a function of V and T. I learned two things from this program. First, I learned that as the moving charged particle approaches the observer plane the electric field at the observer initially increases slowly but then rapidly increases toward infinity as it approaches the observer. Second, through comparison of the electric field strengths of runs at different particle velocities as a function of time it was indicated that velocity forces fields away from the trajectory of the charged particle as suggested above through algebraic approximation. The pattern was not clear as regards the magnetic field.

Program #2 is in Appendix #2. In this program the product of velocity (V) and time (T) was held constant and velocity was incremented so that the program compared particles of different velocity when they were at the same position in space. In my

limited exploration of the system, I found that for all observers the electric field decreased as the velocity increased. Apparently I had never performed a run far enough away from the trajectory of the charged particle. I also found through comparison of individual observers that perceived electric field strengths increased with radial distance from the trajectory of the charged particle. I wrote Program #3 as an attempt to explore this issue (see Appendix #3).

Program #3 holds V, T and X constant and incremented R from one to 2,000 meters in an attempt to perceive the shape of the field strength. As R increased the magnitude of the electric vector increased in a linear fashion over all values of R considered.

CONCLUSION

Both algebraic analysis and numerical experimentation has shown that velocity decreases electric field strength along the particle trajectory. Near the particle trajectory the electric fields tend to increase with increasing radial distance from the trajectory path. This has been seen both algebraically and numerically. Observers near a rapidly moving particle sense an electric field that is decreased when compared to the field produced by a more slowly moving particle. This phenomenon was only seen numerically. We never observed an electric field higher that the static field as suggested by our algebraic work. I think we simply never performed a computer run with an observer far enough away to observe this effect.

The next step in our research is a detailed numerical search

for each of the algebraic findings. Program #3 will be used for this endeavor. Following this I will accomplish algebraic analysis on the magnetic field and will understand the evolution of these fields as a function of particle velocity. Finally, I will study accelerated particle motion.

```
DECLARE FUNCTION XCOMP# (X#, Y#, Z#, CHARGE#, VELA#, TIME#, CONSTA#, N#)
DECLARE FUNCTION MAG# (VEL#, VAR#, N#, CHARGE#)
DECLARE FUNCTION NCAL# (VEL#, TIME#, X#, Y#, Z#)
DECLARE FUNCTION EXT# (CHARGE#, VAR#, N#)
DEFDBL A-Z

CLS
VEL# = 0
DELT = 1D-17
LIMIT = 5D-12
CHARGE# = -1.602192D-19
TIME# = (1 / 3) * 10 ^ (-8)
CONSTA# = 8987550000#


OPEN "ORIGIN.DAT" FOR OUTPUT AS #1
OPEN "Y-1.DAT" FOR OUTPUT AS #2
OPEN "Y-2.DAT" FOR OUTPUT AS #3
OPEN "MY-1.DAT" FOR OUTPUT AS #4
OPEN "MY-2.DAT" FOR OUTPUT AS #5

'*******************************************************************************

VEL = VEL * .0000003

DO

  X = 0
  Y = 0
  Z = 0
  N# = NCAL(VEL#, TIME#, X, Y, Z)
  E1 = XCOMP(X, Y, Z, CHARGE#, VEL#, TIME#, CONSTA#, N#)
  WRITE #1, VEL#, E1#

  X = 0
  Y = 1
  Z = 0
  N# = NCAL(VEL#, TIME#, X#, Y#, Z#)
  E1# = XCOMP(X, Y, Z, CHARGE#, VEL#, TIME#, CONSTA, N#)
  E2# = EXT(CHARGE#, Y#, N#)
  MAGNI# = SQR((E1# ^ 2) + (E2# ^ 2))
  WRITE #2, VEL, MAGNI
  WRITE #2, E1
  WRITE #2, E2
  H3 = MAG(VEL#, Y#, N#, CHARGE#) * CONSTA
  WRITE #4, VEL, H2

  X = 0
  Y = 5
  Z = 0
  N = NCAL(VEL#, TIME#, X#, Y#, Z#)
  E1 = XCOMP(X, Y, Z, CHARGE, VEL, TIME, CONSTA, N)
  E2 = EXT(CHARGE, Y, N) * CONSTA
  MAGNI = SQR((E1 ^ 2) + (E2 ^ 2))
  WRITE #3, VEL, MAGNI
  WRITE #3, E1
  WRITE #3, E2
  H3 = MAG(VEL#, Y#, N#, CHARGE#) * CONSTA
  WRITE #5, VEL, H2

  TIME# = TIME# + DELT

LOOP UNTIL TIME# >= (LIMIT + DELT)

CLOSE #1
CLOSE #2
CLOSE #3
CLOSE #4
CLOSE #5
```

```
END

FUNCTION EXT (CHARGE, VAR, N)

EXT = (CHARGE * VAR) / N

END FUNCTION

FUNCTION MAG (VEL1, VAR, N1, CHARGE1)

HINTER1 = VEL1 / .0000003
HINTER2 = HINTER1 * CHARGE1
HINTER3 = VAR / N1
MAG = HINTER2 * HINTER3

END FUNCTION

FUNCTION NCAL# (VEL, TIME, X1, Y1, Z1)

NINTER1 = SQR(1 - ((VEL / .0000003) ^ 2))
NINTER2 = (X - (VEL * TIME)) ^ 2
NINTER3 = (1 - ((VEL / .0000003) ^ 2))
NINTER4 = NINTER2 / NINTER3
NINTER5 = (SQR(NINTER4 + (Y ^ 2) + (Z ^ 2)))
NINTER6 = NINTER5 ^ 3
NCAL# = NINTER1 * NINTER6


END FUNCTION

FUNCTION XCOMP (X, Y, Z, CHARGE, VEL, TIME, CONSTA, N)
E1ENTER1 = (X - (VEL * TIME#))
E1ENTER = CHARGE * E1ENTER1
XCOMP = (E1ENTER / N) * CONSTA
END FUNCTION
```

```
DECLARE FUNCTION XCOMP# (X#, Y#, Z#, CHARGE#, VELA#, TIME#, CONSTA#, N#)
DECLARE FUNCTION MAG# (VEL#, VAR#, N#, CHARGE#)
DECLARE FUNCTION NCAL# (VEL#, TIME#, X#, Y#, Z#)
DECLARE FUNCTION EXT# (CHARGE#, VAR#, N#)
DEFDBL A-Z

CLS
VELA# = 0
CHARGE# = -1.602192D-19
TIME1# = (1 / 3) * 10 ^ (-8)
CONSTA# = 8987550000#


OPEN "ORIGIN.DAT" FOR OUTPUT AS #1
OPEN "Y-1.DAT" FOR OUTPUT AS #2
OPEN "Y-2.DAT" FOR OUTPUT AS #3
OPEN "MY-1.DAT" FOR OUTPUT AS #4
OPEN "MY-2.DAT" FOR OUTPUT AS #5

'*******************************************************************************


DIST# = (.01 * .0000003) * TIME1#

DO
 VELA# = VELA# + .01
 VEL# = VELA# * .0000003
 TIME# = DIST# / VEL#

X = 0
Y = 0
Z = 0
N# = NCAL(VEL#, TIME#, X, Y, Z)
E1 = XCOMP(X, Y, Z, CHARGE#, VEL#, TIME#, CONSTA#, N#)
WRITE #1, VEL#, E1#

X = 0
Y = 1
Z = 0
N# = NCAL(VEL#, TIME#, X#, Y#, Z#)
E1# = XCOMP(X, Y, Z, CHARGE#, VEL#, TIME#, CONSTA, N#)
E2# = EXT(CHARGE#, Y#, N#)
MAGNI# = SQR((E1# ^ 2) + (E2# ^ 2))
WRITE #2, VEL, MAGNI
WRITE #2, E1
WRITE #2, E2
H2 = MAG(VEL#, Y#, N#, CHARGE#) * CONSTA
WRITE #4, VEL, H2

X = 0
Y = 5
Z = 0
N = NCAL(VEL#, TIME#, X#, Y#, Z#)
E1 = XCOMP(X, Y, Z, CHARGE, VEL, TIME, CONSTA, N)
E2 = EXT(CHARGE, Y, N) * CONSTA
MAGNI = SQR((E1 ^ 2) + (E2 ^ 2))
WRITE #3, VEL, MAGNI
WRITE #3, E1
WRITE #3, E2
H2 = MAG(VEL#, Y#, N#, CHARGE#) * CONSTA
WRITE #5, VEL, H2

LOOP UNTIL VELA >= .99

CLOSE #1
CLOSE #2
CLOSE #3
CLOSE #4
CLOSE #5
```

```
END

FUNCTION EXT (CHARGE, VAR, N)

EXT = (CHARGE * VAR) / N

END FUNCTION

FUNCTION MAG (VEL1, VAR, N1, CHARGE1)

HINTER1 = VEL1 / .0000003
HINTER2 = HINTER1 * CHARGE1
HINTER3 = VAR / N1
MAG = HINTER2 * HINTER3

END FUNCTION

FUNCTION NCAL# (VEL, TIME, X1, Y1, Z1)

NINTER1 = SQR(1 - ((VEL / .0000003) ^ 2))
NINTER2 = (X - (VEL * TIME)) ^ 2
NINTER3 = (1 - ((VEL / .0000003) ^ 2))
NINTER4 = NINTER2 / NINTER3
NINTER5 = (SQR(NINTER4 + (Y ^ 2) + (Z ^ 2)))
NINTER6 = NINTER5 ^ 3
NCAL# = NINTER1 * NINTER6


END FUNCTION

FUNCTION XCOMP (X, Y, Z, CHARGE, VEL, TIME, CONSTA, N)
E1ENTER1 = (X - (VEL * TIME#))
E1ENTER = CHARGE * E1ENTER1
XCOMP = (E1ENTER / N) * CONSTA
END FUNCTION
```

```
DECLARE FUNCTION EXT# (CHARGE#, VAR#, N#)
DECLARE FUNCTION XCOMP# (X#, Y#, Z#, CHARGE#, VEL#, TIME#, CONSTA#, N#)
DECLARE FUNCTION NCAL# (VEL#, TIME#, X#, Y#, Z#)
DEFDBL A-Z

CLS
VEL# = .58 * .0000003
CHARGE# = -1.602192D-19
TIME# = (1 / 3) * 10 ^ -8
CONSTA# = 8987550000#

OPEN "Y-DIST.GRA" FOR OUTPUT AS #1


'*******************************************************************************

X = 0
Y = 0
Z = 0

DO
 Y# = Y# + 1
 N = NCAL(VEL#, TIME#, X, Y, Z)
 E1# = XCOMP(X, Y, Z, CHARGE#, VEL#, TIME#, CONSTA#, N#)
 E2# = EXT(CHARGE#, Y#, N#) * CONSTA
 MAGNI = SQR((E1 ^ 2) + (E2 ^ 2))
 WRITE #1, Y, MAGNI

LOOP UNTIL Y# = 2000

CLOSE #1

END

FUNCTION EXT (CHARGE, VAR, N)

EXT = (CHARGE * VAR) / N

END FUNCTION

FUNCTION NCAL# (VEL, TIME, X1, Y1, Z1)

NINTER1 = SQR(1 - ((VEL / .0000003) ^ 2))
NINTER2 = (X - (VEL * TIME)) ^ 2
NINTER3 = (1 - ((VEL / .0000003) ^ 2))
NINTER4 = NINTER2 / NINTER3
NINTER5 = (SQR(NINTER4 + (Y ^ 2) + (Z ^ 2)))
NINTER6 = NINTER5 ^ 3
NCAL# = NINTER1 * NINTER6


END FUNCTION

FUNCTION XCOMP (X, Y, Z, CHARGE, VEL, TIME, CONSTA, N)
E1ENTER1 = (X - (VEL * TIME#))
E1ENTER = CHARGE * E1ENTER1
XCOMP = (E1ENTER / N) * CONSTA
END FUNCTION
```

A RESEARCH STUDY OF HOW ALCOHOL AND AVIATION MIX

Christine Fern

Final Report for:
Summer Research Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
Brooks Air Force Base, San Antonio, TX

August 1992

A RESEARCH STUDY OF HOW ALCOHOL AND AVIATION MIX

Christine Fern

Abstract

In order to get the best overall perspective of alcohol and aviation, the past as well as the present must be recognized. Alcohol causes many mental and physical impairments. Low Blood Alcohol Levels (BALs) as well as high BALs result in impairments. There have been studies dealing with hangover effects 14 hours after alcohol consumption, which gathered evidence proving a reduction of memory and processing capacity. Some of the major concerns of alcohol and aviation are that pilots' posses a lack of awareness of hangover effects, of laws and regulations dealing with alcohol and aviation, and of their own performance under the influence. Pilots' self-evaluations are dangerous.

A RESEARCH STUDY OF HOW ALCOHOL AND AVIATION MIX

Christine Fern

INTRODUCTION

Alcohol is a major cause of automobile accidents. What about aviation accidents? In 1963, 43% of fatal civil aircraft accidents were reported to be associated with alcohol (9). Between 1975 and 1981, the National Transportation Safety Board (NTSB) found that 10.5% of the fatal general aircraft crashes involved pilots whose autopsies showed alcohol in the blood (10). Some causes for these fatalities are the effects of alcohol on pilot flight performance. However, the most severe reasons are because pilot self-evaluations are dangerous.

EFFECTS

A standard drink is defined as 1.5 oz. of 8-proof liquor, 12 oz. of beer, or 3 oz. of wine. A standard drink contains approximately 15 grams of alcohol, which results in a Blood alcohol content (BAC) of 0.02% to 0.04%. After one standard drink, it would take a 150-pound person about 2 hours to have a BAC of zero (3).

Alcohol is primarily a central nervous system depressant. Just one drink (0.02%) of alcohol impairs judgement and makes it hard for a person to track moving objects. Two or more drinks impairs thought, judgement, and motor skills. Although these levels are considered to be low BALs, a pilot may be experiencing planning and performance errors, procedural errors, and communication errors. All of these important for a pilot to maintain (5).

Alcohol can also cause quick, impulsive actions, a pilot wouldn't normally even think of. Alcohol can also effects the inner ear, which causes a pilot's visual control to be impaired. One of the main effect on a pilot is nystagmic eye movements, which is caused by head movements. This particular effect makes it extremely difficult to perceive the aircraft's altitude and visual fixation, not to mention a pilot's tracking ability (3).

Hangover effects, when the body has a BAL of zero, but is still effected by the alcohol many hours later. For example, working memory capacity is reduced. Along with that, a pilot's attention cannot be divided between two or more tasks or two or more objects (10).

PILOTS' ATTITUDES

Pilots' attitudes towards drinking and flying determine the educational programs created to inform pilots of the causes and effects of flying and drinking alcohol. Ross & Ross sent out questionnaires to a number of licensed pilots to collect data from them about their attitudes in this matter. Some of the data are graphed in the following figures. In the questionnaire, the pilots were asked several questions about the frequency and amount of alcoholic beverages that they consume in a given period of time. The data collected placed the pilots in one of five drinking categories. The categories are: abstain, frequent, light, moderate, and heavy (7).

The pilots were asked to estimate the number of drinks safe to consume 3 hours before flying and before driving. Figures 1 shows the median results of three drinking categories. It is important to note that as the drinking categories get more severe, the number of drinks judged safe increases. The graph shows that the substantial difference between driving and flying is held constant through all categories of drinking behavior. Pilots' are more cautious with drinking and flying than with drinking and driving (7).

Figure 1 Avg. # Of Drinks Judged Safe 3 Hrs.

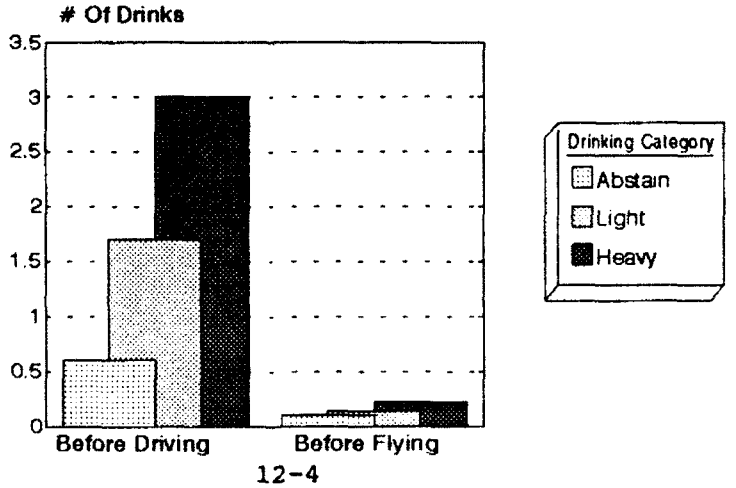
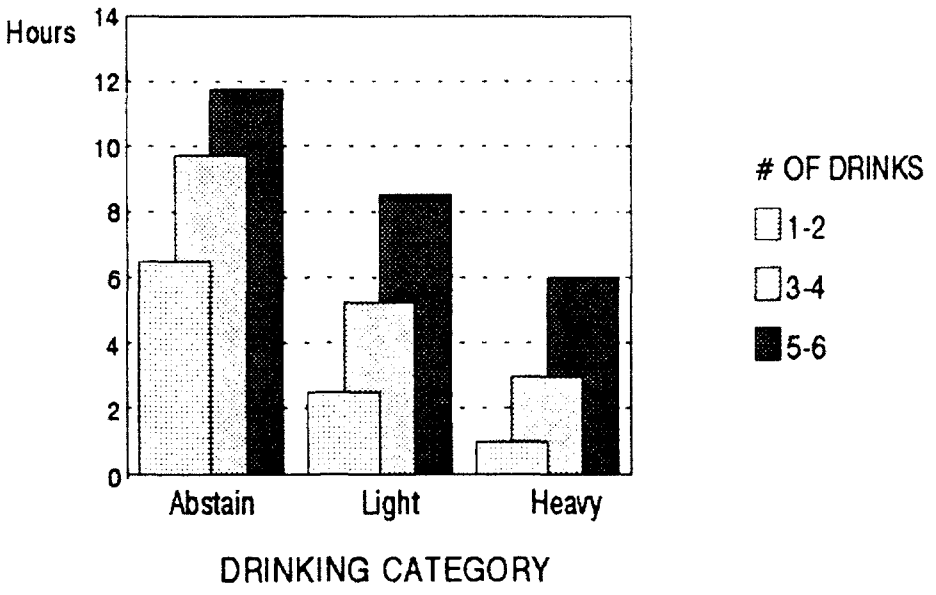


Figure 2-A

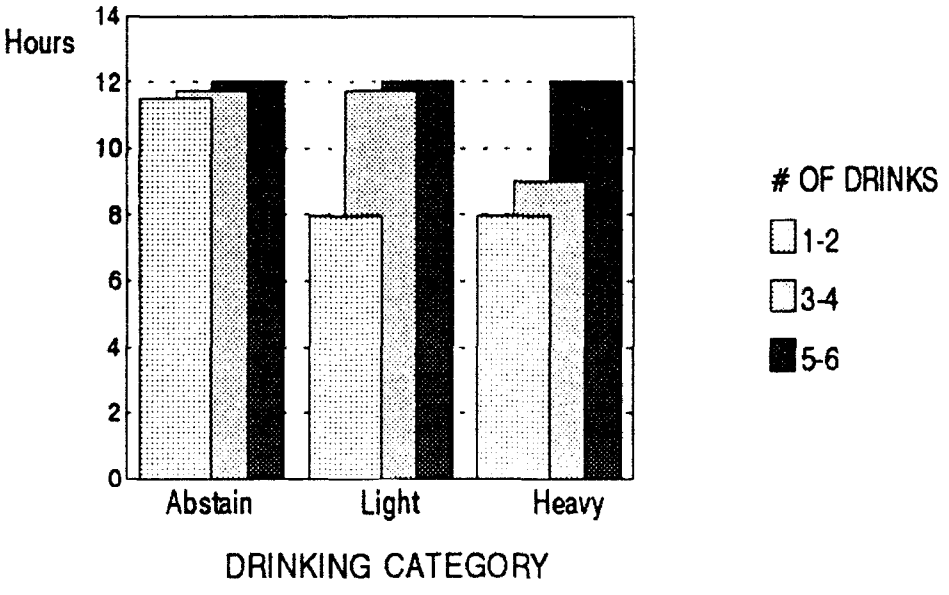
Avg. Waiting Interval Judged Necessary Between Drinking and Driving



Pilots were also asked to estimate the amount of time, in hours, they would wait before driving and flying. As the previous figure, there was a large difference in the responses to driving and flying. For each graph, the pilots in the heavy drinking category waited less time. The pilots categorized in the abstain category waited the most. Very few of the pilots' responses would have resulted in a BAC of zero (7).

Figure 2-B

Avg. Waiting Interval Judged Necessary Between Drinking and Flying



Damkot and Osga surveyed 835 pilots on their attitudes about drinking and flying. The self-reported responses collected put the majority of the subjects in the light to moderate drinkers category by self report. Another series of questions were asked to the same pilots and the results concluded that between 13% to 15% were moderate to heavy drinkers (1).

RULES AND REGULATIONS

There are many rules and regulations controlling the use of alcohol in aviation. In 1985, the Federal Aviation Administrations (FAA) revised the .04% Blood Alcohol Concentration (BAC) Rule. In a study by Ross and Ross less than 50% of pilots were not aware of this law (8). The 8 hour (h) rule states that it is prohibited to flying within 8-h after the consumption of any alcoholic beverage. This rule, like many, is difficult to enforce, because it is difficult to prove. Many pilots are aware of the 12 h "bottle to throttle" rule, which prohibits pilots to fly within 12 hours of consuming alcoholic beverages (3).

For future overseeing of alcohol and aviation, the FAA has proposed a rule that will mean the loss of 10,000 pilots licenses. This proposed rule will affect pilots whose drivers licenses are suspended due to a DWI or DUI in the past 7 years (2). As a result of significant hangover effects, a 48 h rule is hoped to reduce unsafe flying (3).

CONCLUSION

It is dangerous to drink and drive and drink and fly, but it is more dangerous to estimate the amount of alcohol one has consumed. Furthermore, it is dangerous to think that the effects of alcohol stop when the BAL is at zero. Drinkers in the heavy category are more likely to underestimate just how much alcohol was consumed. It is a good idea to know the rules and regulations about drinking and flying as well as drinking and driving. Do not go away thinking that you know it all, remember, self-evaluations are dangerous...pilot or not.

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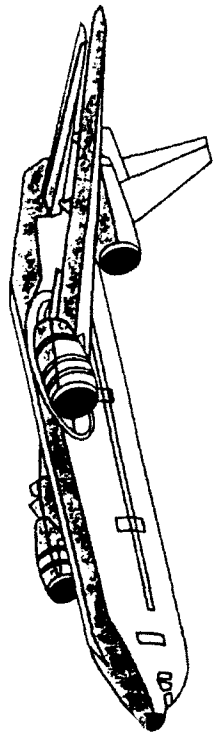
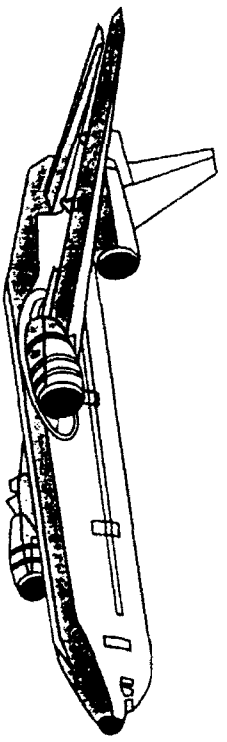
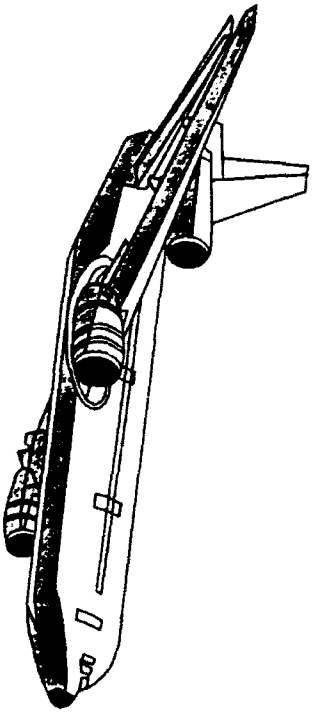
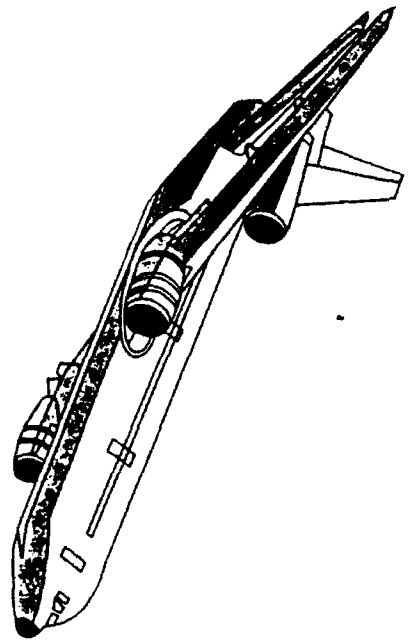
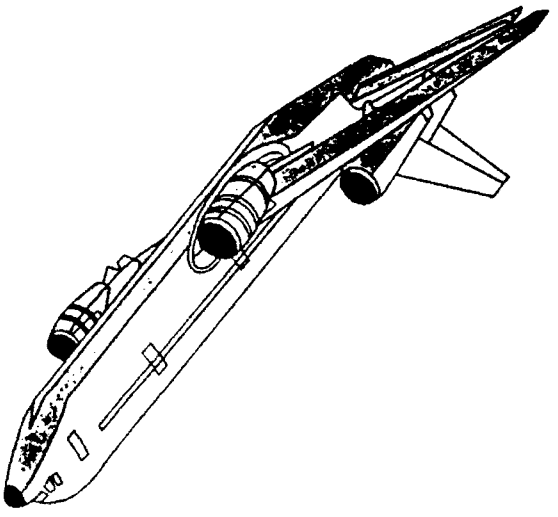




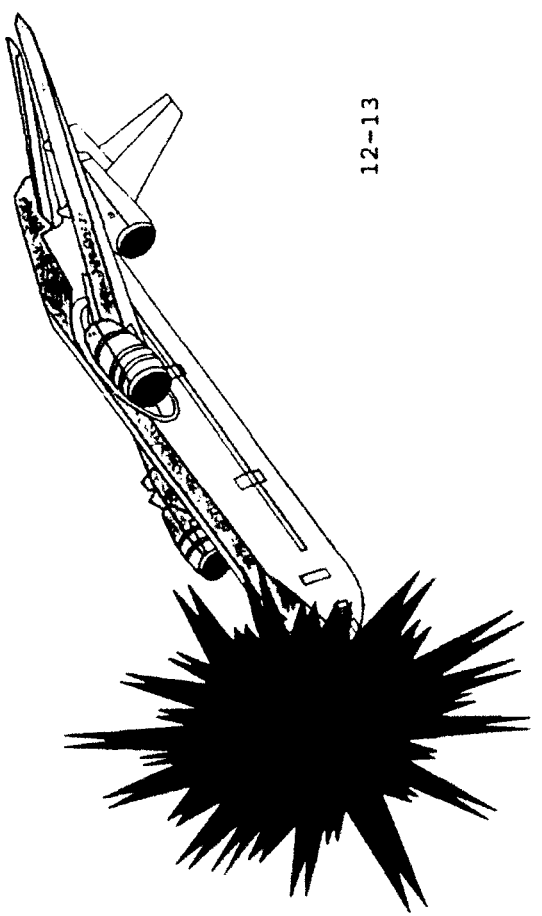






Alcohol & Aviation

Any Questions?



A STUDY OF THE TRANSFER OF PERCHLOROETHYLENE IN THE MILK OF LACTATING MOTHERS

D. Joshua Finch

Final Report for:
High School Apprenticeship Program
Armstrong Laboratory

Sponsored by:
Armstrong Laboratory
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August 1992

A STUDY OF THE TRANSFER OF PERCHLOROETHYLENE IN THE MILK OF LACTATING MOTHERS

D. Joshua Finch

Abstract

The amount of perchloroethylene in the milk of exposed female rats was studied. The amount of protein and triglyceride present in human milk samples was measured. Partition coefficients for the chemical were also established for each sample. The results indicate that the partition coefficient increased with the amount of triglyceride in each sample. The findings from the rat kinetic studies along with the partition coefficients found from the human milk samples can then be used to generate a computer model that will predict the amount of perchloroethylene that is transferred from a human mother's milk to her nursing infant.

A STUDY OF THE TRANSFER OF PERCHLOROETHYLENE IN THE MILK OF LACTATING MOTHERS

D. Joshua Finch

INTRODUCTION

Many women in the armed forces, and in industries such as dry cleaning, use volatile chemicals like perchloroethylene every day. When these women give birth and return to the workplace there is a chance that the nursing infant could be exposed to the chemical through the mothers milk. It is therefore necessary to know how much of the chemical is distributed to the mothers milk. By learning more about the way that these chemicals are absorbed and distributed it will be possible to reduce the nursing child's risks of exposure.

METHODOLOGY and MATERIALS

Reagents

The Coomassie Protein Assay reagent was purchased from Pierce. The Triglyceride (GPO-Trinder) reagent and the Lipid Lin-trol set were both purchased from Sigma Diagnostics.

Instrumentation

A **Gilford Response** Uv-Vis spectrophotometer was used to analyze the amount of protein and triglyceride in the human milk samples. The standards, samples, and controls for the triglyceride assay were ran in the spectrophotometer, using the standard curve program with the wavelength set at 540 nm. and the band width set at 2.0 nm. The standards and samples for the protein assay were ran in the spectrophotometer, using the standard curve program with the wavelength set at 595 nm. and the band width set at 2.0 nm.

Partition coefficients were calculated by analyzing the samples on a **Tekmar** 7000 headspace autosampler and a **Hewlett Packard** 5890 Series II gas chromatograph with a flame ionization detector. The gas chromatograph was installed with a **VOCOL** 0.53 mm(internal diameter) x 30 m column purchased from Supelco.

Procedure

The standards and samples for the protein assay were prepared in 15 mm x 85 mm glass test tubes. 2.5 mL of the Coomassie reagent was pipetted into each of the test tubes. Bovine Serum Albumin standards were added to five separate test tubes. The concentrations for the standards were zero, 100 ug/mL, 250 ug/ml, 500 ug/mL, and 1000 ug/mL. One mL of each breast milk sample was diluted with 9 mL of saline and mixed thoroughly. One 50 uL sample and three 10 uL sample were then added to the labeled test tubes containing the Coomassie reagent. All standards and samples were then vortex mixed and allowed to equilibrate for 15 minutes at room temperature. The standards and samples were then run on the **Gilford Response** Uv-Vis spectrophotometer using the previously mentioned parameters. The results can be seen in Table 1.

The standards, samples, and controls for the triglyceride assay were also prepared in 15 mm x 85 mm glass test tubes. The Triglyceride (GPO Trinder) reagent was reconstituted with 10 mL of saline and mixed by inversion. Then, one mL of the reagent was pipetted into each of the test tubes. Ten uL of each standard was placed into the appropriately labeled test tubes. The concentrations for the standards were zero, 200 mg/dL, 523 mg/dL, and 1000 mg/dL. One mL of each breast milk sample was diluted with 9 mL of saline and mixed thoroughly. Ten uL of the diluted breast milk was added to the appropriately labeled test tubes. Each sample was run in triplicate. 100 uL of Lipid Lin-trol was diluted with an equal amount of saline and 10 uL of this dilution was added to three labeled test tubes containing the Triglyceride (GPO Trinder) reagent. All standards, samples, and controls were vortex mixed and allowed to equilibrate for fifteen minutes at room temperature. They were then analyzed on the **Gilford Response** Uv-Vis spectrophotometer. The results can be seen in Table 2.

Twenty mL vials were used to analyze the breast milk to air partition coefficients on the headspace autosampler. 200 milligrams of milk were dispensed into each vial. The vials were then capped with **Teflon**-coated rubber septa. 1.0 mL of headspace from a 10000 ppm bag of perchloroethylene

was added sample and reference vials. Helium was used as a carrier gas at 9.3 mL/min. The samples were incubated for three hours at 37 degrees celsius before headspace and GC/FID analysis. The data was collected using the Nelson data acquisition system.

TABLE 1

0 sample id	1 triglyceride grams/liter	2 triglyceride sd
1 cont 15jun92 mean	15.765	0.664
2 cont 18jun92 mean	15.703	0.068
3 cont10jul92 mean	13.659	1.260
4 cont16jun92 mean	15.657	0.555
5 cont16jun92 mean	15.703	0.068
6 cont1jul92 mean	18.783	1.346
7 cont6jul92 mean	13.883	1.002
8 cont8jul92 mean	11.517	0.439
9 dm 22jun92 mean	11.130	4.423
10 dm 10jul92 1000 mean	8.012	0.729
11 dm8jul92 1000 mean	21.643	2.026
12 dm9jul92 1000 mean	23.072	2.307
13 mjw10jan92 1030 mean	91.473	15.965
14 mjw10jan92 1800 mean	44.323	23.470
15 mjw12dec91 0800 mean	30.717	3.959
16 mjw15dec91 0100 mean	11.753	2.119
17 mjw17dec91 0930 mean	28.033	3.609
18 mjw24dec91 mean	26.243	10.967
19 mjw5jan92 mean	50.427	9.351
20 mmk 1may92 mean	6.540	0.602
21 mmk 5mar92 mean	16.330	4.239
22 mmk11jun92 0945 mean	23.803	1.597
23 mmk11jun92 froz mean	26.706	1.398
24 mmk11mar92 mean	15.083	4.339
25 mmk12mar92 mean	24.630	0.344
26 mmk15apr92 mean	26.363	12.674
27 mmk16apr92 mean	23.823	3.685
28 mmk16jun92 mean	50.397	4.285
29 mmk16mar92 mean	12.720	5.482
30 mmk18mar92 mean	26.563	3.420
31 mmk1apr92 mean	28.970	5.052
32 mmk1may92 mean	4.233	3.955
33 mmk28may92 mean		
34 mmk5mar92 mean	16.330	4.239
35 mmk6apr92 mean	15.507	5.517
36 mmk7apr92 mean	25.070	6.145
37 mmk8apr92 mean	20.490	2.865
38 mmk9apr92 mean	24.457	3.194
39 tx2 mean	17.597	2.627
40 tx3 mean	32.127	6.148
41 tx5 mean	19.094	2.443
42 tx6 mean	13.193	2.586
43 tx7 mean	6.800	0.701

TABLE 2

0 sample id	1 mean protein grams/liter	2 protein sd
1 cont 15jun92 mean		
2 cont 18jun92 mean		
3 cont10jul92 mean		
4 cont16jun92 mean		
5 cont16jun92 mean		
6 cont1jul92 mean		
7 cont6jul92 mean		
8 cont8jul92 mean		
9 dm 22jun92 mean	8.201	2.198
10 dm10jul92 1000 mean	7.721	4.121
11 dm8jul92 1000 mean	5.651	1.642
12 dm9jul92 1000 mean	6.716	0.990
13 mjw10jan92 1030 mean	10.621	1.527
14 mjw10jan92 1800 mean	8.846	3.078
15 mjw12dec91 0800 mean	11.447	1.910
16 mjw15dec91 0100 mean	7.877	1.965
17 mjw17dec91 0930 mean	9.829	3.275
18 mjw24dec91 mean	7.697	0.915
19 mjw5jan92 mean	9.153	1.567
20 mmk 1may92 mean	4.408	0.156
21 mmk 5mar92 mean	13.103	5.474
22 mmk11jun92 0945 mean	10.860	1.884
23 mmk11jun92 froz mean		
24 mmk11mar92 mean	14.829	6.072
25 mmk12mar92 mean	15.389	4.856
26 mmk15apr92 mean	11.770	2.801
27 mmk16apr92 mean	14.083	5.518
28 mmk16jun92 mean	12.798	3.372
29 mmk16mar92 mean	12.789	3.339
30 mmk18mar92 mean	15.337	5.677
31 mmk1apr92 mean	12.580	3.300
32 mmk1may92 mean	9.751	1.324
33 mmk28may92 mean	11.530	0.376
34 mmk5mar92 mean	13.103	5.474
35 mmk6apr92 mean	17.864	7.965
36 mmk7apr92 mean	10.712	2.730
37 mmk8apr92 mean	11.498	2.531
38 mmk9apr92 mean	11.888	2.171
39 tx2 mean	12.313	2.081
40 tx3 mean	9.564	1.248
41 tx5 mean	18.345	0.232
42 tx6 mean	14.171	2.637
43 tx7 mean	32.073	1.107

RESULTS

When the protein and triglyceride data were analyzed there was no positive correlation could be made between the protein level and the milk air partition coefficient. Further research would be necessary to determine a correlation between the two parameters. The triglyceride level, on the other hand, clearly has an effect on the partition coefficient. As the triglyceride level increases, the milk air partition coefficient also increases. In samples taken from "mmk" and "dm" it is evident that a correlation exists between the increase in triglyceride and the increase in the partition coefficient. This correlation is shown in Figure 1 and Figure 2.

FIGURE 1

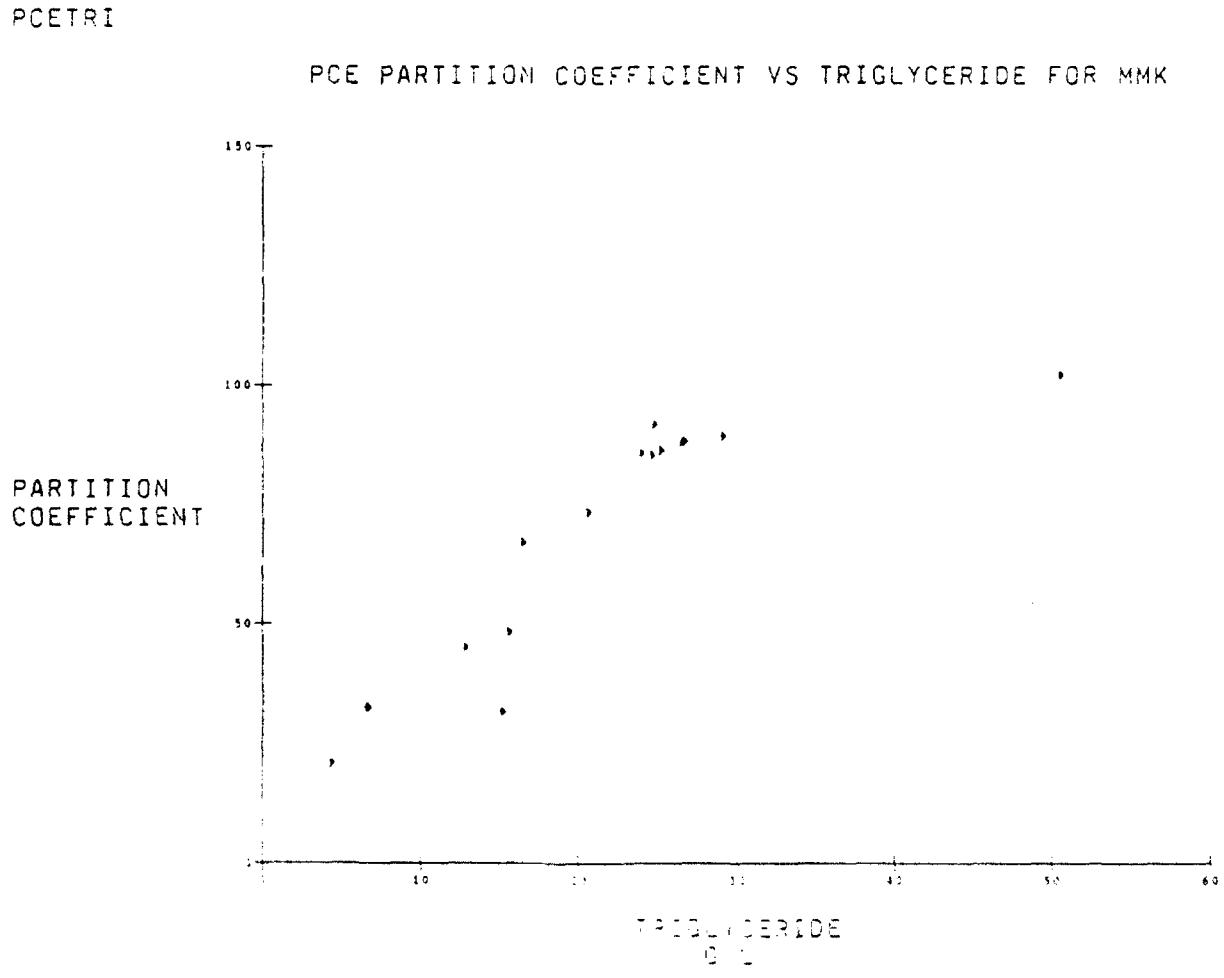
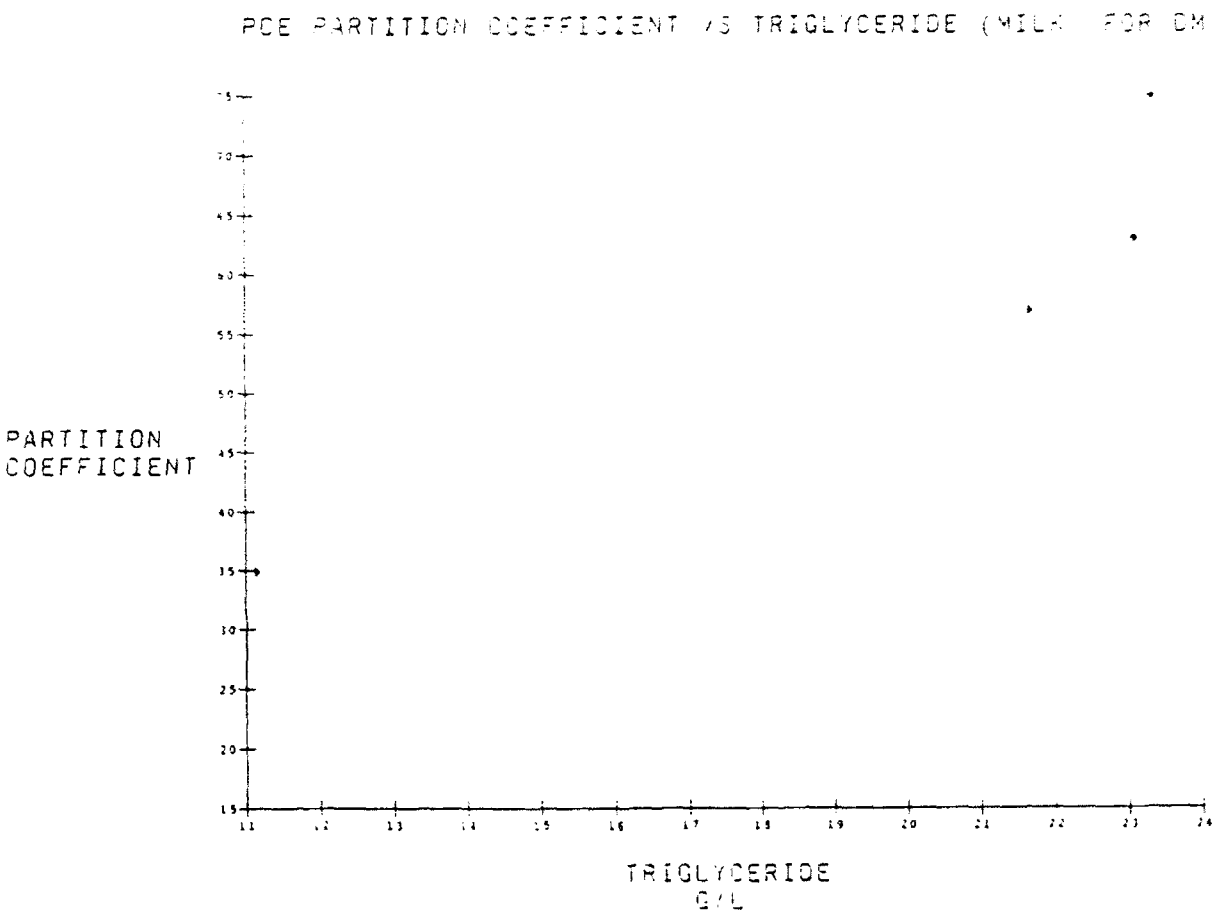


FIGURE 2



CONCLUSION

The triglyceride level in breast milk correlates with the perchloroethylene milk to air partition coefficient. This indicates that triglyceride levels are an important parameter when modeling the lactational transfer of perchloroethylene. The variability of this parameter must be considered in a risk assessment for the nursing infants of lactating women that work with perchloroethylene.

EFFECT OF HYPOXIA ON RESPIRATORY FREQUENCY, HEART RATE, AND OXYGEN SATURATION IN HUMAN MALES

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Bolling Air Force Base, Washington, D.C.

10 August 1992

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ABSTRACT

During flight, crew members are exposed to the potential stressors of high sustained G (HSG) and hypoxia. Because the changes in respiratory frequency (RF), heart rate (HR), and arterial oxygen saturation (SaO2) are thought to be similar for both HSG and hypoxia, it is important to determine the effect of these stressors individually. RF, HR, and SaO2 changes were measured in 7 human male subjects who breathed, in series, 6 different gas mixtures (FIO2): 12%, 14%, 16%, 18%, 20%, and 60% oxygen. The results indicate that RF was not consistently altered by changes in FIO2. HR was consistently and significantly ($p<0.05$) increased between the time the subjects began breathing the gas mixture (i.e., begin-gas, baseline) and 15 min later (i.e., end-gas) for all FIO2 groupings, but there were no significant differences within baseline or end-gas values for any FIO2. Changes in SaO2 were inversely related to FIO2 and significantly different between FIO2 groupings between 12% and 20%. No significant change in SaO2 was detected between 20% and 60% FIO2.

EFFECT OF HYPOXIA ON RESPIRATORY FREQUENCY, HEART RATE, AND OXYGEN SATURATION IN HUMAN MALES

Stephanie J. Garcia

INTRODUCTION

It is well known that high performance military aircraft create risks and possible hazards (e.g., hypoxia, high sustained G-forces) for aircrew (5). Concern for those personnel and crew has prompted several investigations that seek to prolong G duration time, increase G tolerance, and protect the safety of the pilot. During high sustained +Gz (HSG), blood from the head tends to be pooled in the lower part of the body, preventing the blood supply to the brain (6). As a consequence, the aircrew may experience G-induced loss of consciousness (G-LOC). G-LOC is a state of altered perception that has been described as "fainting in the air" by early World War II pilots (1).

Also, without adequate protection, the low pressure environment experienced during flight may result in a decreased supply of oxygen (hypoxia) to the body. Hypoxia may impair cellular function, alter brain function, deteriorate performance, reduce visual function, and cause loss of consciousness (11). Symptoms of hypoxia are not always recognizable, and, because of the complexity of high performance aircraft and the immediate responses necessary to maintain control, the impairment from hypoxia for only a few seconds may endanger the pilot.

Hypoxia in aviation results from the decrease in atmospheric pressure associated with altitude, and the symptoms are similar to those observed during HSG, where blood oxygen saturation (SaO2) may be

decreased (2). What is not well understood is the effect of exposing an individual simultaneously to HSG and hypoxia. To understand that response, an evaluation of the individual effects of these stressors on respiratory frequency, heart rate, and arterial blood oxygen saturation (SaO2) is needed. Preliminary results from exposure of human males to varying levels of inspired oxygen (FIO2) during normobaria (i.e., sea level pressure) are reported here.

MATERIALS AND METHODS

Subjects: Subjects for this report consisted of seven males from the Armstrong Laboratory acceleration panel. The age (26.8 $\pm$ 1.2 yr, Mean $\pm$ SE), height (173.3 $\pm$ 3.2 cm), and weight (75.5 $\pm$ 2.5 kg) of these subjects were similar to those previously reported (3). Each subject received hypoxia training which included breathing 12 percent oxygen at 1 G and using an Air Force aviator's oxygen mask (Model MBU-20/P) without positive pressure breathing (PPB). This training provided an opportunity for the subject to experience breathing gas through a mask and as well as hypoxic symptoms. The subject's baseline arterial blood saturation (SaO2) was also collected at this time.

Inspired gas mixtures: Tanked gas concentrations of 12%, 14%, 16%, 18%, and 20% oxygen, balanced with nitrogen, were used to simulate altitudes from 4,267 meters (14,000 ft) to approximately sea level (168 ft). The 60% inspired oxygen was used to provide one hyperoxic condition. To assure accuracy, the percent oxygen breathed from the tanked gas was verified after each exposure by mass spectrometry (Perkin-Elmer, Model

1100, Medical Gas Analyzer). The subjects were exposed to each gas mixture in series and in semi-random order; subjects were unaware of which inspired gas mixture they were breathing.

Measurements: Measurements included respiratory frequency (breaths per minute, BPM), heart rate (beats per minute, BPM), and blood oxygen saturation (SaO2, %). Respiratory frequency (RF) was determined from mask gas flow waveforms. Heart rate (HR) was determined from EKG waveforms. Arterial blood saturation (SaO2) was determined using an ear oximeter (Hewlett-Packard, Model 47201A) and recorded, as for RF and HR, on a strip chart recorder (Gould, Model 2800s).

Experimental Procedure: At the beginning of the experiment, subjects donned the EKG electrodes an oxygen mask, and a helmet liner. The ear oximeter was attached to a specially fabricated bracket on the helmet liner. After the EKG leads were accessed for data collection, the subject began breathing the gas mixture selected for that day. The test was terminated if the SaO2 dropped below 60% or for reasons determined by the medical monitor.

Statistical Analysis: Results were compared statistically using one factor repeated measures ANOVA. Changes were considered significant when $p<0.05$.

RESULTS

Respiratory Frequency: There appeared to be no consistent change in RF between the begin-gas (baseline) or the end-gas (15 min later) groupings

for any FIO2 (Table 1). The percent change in RF decreased from the begin-gas to the end-gas for 12%, 18%, and 60% FIO2 groups, but increased for 14%, 16%, and 20% FIO2. There were no significant differences within the begin-gas, end gas, or % change columns (Table 1), except that, in the latter, 12% differed ($p<0.05$) from 14%, 16% and 20% FIO2..

Table 1.

Changes in respiratory frequency of 7 male subjects breathing different FIO2 for 15 minutes. All values are expressed as Mean ± SE

	Respiratory Frequency (BPM)		
FIO2 (%)	Begin-Gas	End-Gas	% Change*
12%	19.3 ± 1.7	15.9 ± 1.1	- 14.8 ± 8.5
14%	15.4 ± 1.5	15.9 ± 1.3	+ 6.2 ± 7.6
16%	16.7 ± 1.9	18.0 ± 1.1	+ 10.9 ± 7.2
18%	18.9 ± 1.6	17.6 ± 0.7	- 2.1 ± 9.8
20%	17.1 ± 1.1	17.1 ± 1.4	+ 1.3 ± 8.7
60%	17.6 ± 1.2	16.7 ± 0.6	- 2.8 ± 7.0

* % Change = $\frac{\text{end-gas value - begin-gas value}}{\text{begin-gas value}} \times 100$

Heart Rate: The HR consistently and significantly increased (Table 2) between begin-gas (baseline) and end-gas (15 min later) groupings for all FIO2. There were no significant differences within the begin-gas, end-gas, or percent change columns.

Arterial Oxygen Saturation (SaO2): The changes in SaO2 depended on the percent oxygen in the breathed gas, for, as the oxygen concentration increased, the percent decrease in SaO2 became less pronounced (Table 3). At 60% oxygen, a slight increase in SaO2 was observed between the

begin-gas and end-gas groupings. In the % change column, 20% and 60% differed ($p<0.05$) only from 12% and 14% FIO2.

Table 2.

Changes in heart rate of 7 male subjects breathing different FIO2 for 15 minutes. All values are expressed as Mean ± SE

	Heart Rate (BPM)		
FIO2 (%)	Begin-Gas	End-Gas	% Change*
12%	84.2 ± 3.9	115.4 ± 6.1	+36.0 ± 7.7
14%	82.4 ± 4.2	113.0 ± 6.3	+37.7 ± 5.4
16%	85.2 ± 6.5	112.5 ± 6.9	+36.5 ± 6.0
18%	86.0 ± 6.9	116.8 ± 5.7	+41.0 ± 9.6
20%	83.6 ± 3.7	106.0 ± 5.2	+27.0 ± 6.1
60%	80.2 ± 3.8	109.6 ± 6.6	+35.8 ± 5.9

* % Change = $\frac{\text{end-gas value - begin-gas value}}{\text{begin-gas value}} \times 100$

Table 3.

Changes in arterial blood oxygen saturation (SaO2) of 7 male subjects breathing different FIO2 for 15 minutes. All values are expressed as Mean ± SE

	Arterial Blood Oxygen Saturation (%)		
FIO2 (%)	Begin-Gas	End-Gas	% Change*
12%	96.5 ± 0.5	82.2 ± 2.8	- 14.9 ± 2.4
14%	96.4 ± 0.6	89.9 ± 1.3	- 6.7 ± 1.3
16%	96.5 ± 0.3	94.9 ± 0.5	- 1.7 ± 0.3
18%	95.7 ± 0.6	94.1 ± 0.5	- 1.6 ± 0.7
20%	96.0 ± 0.3	95.8 ± 0.6	- 0.2 ± 0.5
60%	96.2 ± 0.5	98.3 ± 0.4	+ 2.1 ± 0.3

* % Change = $\frac{\text{end-gas value - begin-gas value}}{\text{begin-gas value}} \times 100$

DISCUSSION

The body's response to a drop in ambient pressure is a rise in tidal volume, followed by a subsequent increase in respiratory frequency; hyperpnea also may occur as an adjustment to declined oxygen tension in arterial blood (12). In the study reported here (Table 1), no consistent increase in respiration was detected. However, there was an increase at 14% and 16% FIO2. The degree of hypoxia resulting from exposure of 18% FIO2 may not have been sufficient to cause an increase in RF. An explanation is not immediately available for the decrease in RF observed at 12% FIO2.

Heart rate, on the other hand, was consistently and significantly increased as the result of hypoxia, and these results are similar to what has been previously reported (10). The increase in HR observed at 20% FIO2 suggests that factors other than hypoxia also contributed to this increase; those factors could include apprehensiveness due to the slight difficulty in breathing that is associated with an oxygen mask. However, even when the 20% FIO2 HR value is subtracted, a net increase still is observed for all FIO2 including the 60% group. The latter suggests that hyperoxia also may cause an increased HR.

While hypoxia causes an increase in RF and HR, it also is known (7) to decrease arterial blood saturation (SaO2). Normal SaO2 is approximately 96%, but it can fall to an average of 84% while breathing 12% oxygen (compared to breathing 20.9% O2 in air). SaO2 can fall so low that severe decrements in performance and even loss of consciousness can occur (2). Even though increases in FIO2 reduce and sometimes

eliminate the reduction in SaO2 (3), it is not without hazard, and may not be effective (2, 8). However, by administering 100% oxygen, onset of desaturation is delayed and its extent reduced. The begin-gas (baseline) and end-gas values of Table 3 are similar to what has been previously reported (3).

The effects of +Gz acceleration on respiratory frequency, heart rate, and SaO2 are similar to those of hypoxia. For example, during acceleration, breathing rate increases, as pulmonary ventilation increases; the latter appears to be due to a combination of the more rapid breathing rate and the depth of breathing (8). Lung volume decreases are thought to be due to compression caused by the added G load on the lung; the latter results in the closing or constricting of the size of many alveoli in dependent parts of the lung (4).

Concerning the combined effects of the double stressor (hypoxia and +Gz acceleration), Glaister (9) reported that mild hypoxia bears no significant effect on +Gz tolerance and that a reduction in inspired oxygen tension to 70 mm Hg decreases the threshold for blackout by 0.6 G. In addition, when hypoxia is more severe (i.e., O2 tension of 55 mm Hg), the threshold falls by 0.8 - 1.2 G, and often results in unconsciousness. Thus, pilots are supplied with oxygen systems during flight to assure that SaO2 is not reduced.

CONCLUSION

Hypoxia tends to increase respiratory frequency and heart rate, but lower SaO2.

ACKNOWLEDGEMENTS

The voluntary, informed consent of subjects used in this study was obtained as required by AFR 169-3. The research protocol was approved by the USAFSAM Advisopry Committee on Human Experimentation (ACHE).

Special gratitude goes out to Mr. Dan Zavorka for his support and confidence, and for his help in getting me to this apprenticeship program. Also, I would wish to thank all the people that welcomed me and helped me once I arrived, especially Dr. Emerson L. Besch for his wisdom, guidance, and patience. For the use of their computer, thanks to Janet Wiegman, Asha Shahed, Judy Barber, and Grady Ripley.

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MEASURING NON-LINEAR TRANSMITTANCE PROPERTIES OF 1-PHENYLAZO 2-NAPHTHALENOL LASER ABSORBING DYE

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MEASURING NON-LINEAR TRANSMITTANCE PROPERTIES OF 1-PHENYLAZO 2-NAPHTHALENOL LASER ABSORBING DYE

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Abstract

A standard organic dye marketed across The nation as a safe, cheap, economical laser shielding exhibited optical bleaching when safety was put to the test. the dye, 1-Phenylazo 2- Napthalenol, conformed to its marketing when subjected to the relatively minuscule intensities of a spectrophotometer. Yet, the same dye transmitted laser light at higher intensities, intensities it is produced to shield against. An experiment was constructed to observe and to take data *on this phenomenon. The* majority of the project consisted in the production of an environment that adequately produced and recorded the non-linear effects. When the data was plotted approximately three phase shifts were found during the bleaching, or reverse photo saturation, process. This occurrence is yet unexplained and is under continuing research in the Armstrong Laser Laboratory at Brooks AFB.

INTRODUCTION

1-Pheny 2-Nap is an organic dye designed to absorb wavelengths below 520 nm when embedded in a polymer. Theoretically, the polymer embedded dye should properly exhibit absorbency characteristics when exposed to laser light from an Argon-ion laser. This hypothesis corroborated with spectrophotometer readings of the dye's denial of light about the laser's wavelengths. As a result, the dye commercially retails as laser protective shielding. However, when this 'protective' substance is submitted to actual laser radiation at above threshold intensities of irradiance, a phenomenon called reverse photo saturation is evident. Reverse photo saturation is the process in which a light absorbing substance takes in a certain threshold amount of radiation and then transmits a higher percentage of the incident energy. Such substances often serve as Q-switches and mode locking devices in pulsed lasers. Yet, in the azo dye used for protection, reverse photo saturation is not desired and has the chance of obvious hazards to the user. To study these events and produce scientific reasons for their occurrence an experiment was created to determine the correlation of azo dye concentrations to laser irradiance intensity and time exposed. An Argon-ion laser was used as the incident source for the experiments.

SAMPLES

The experiment encompasses the use of samples both commercially available and laboratory produced. The laboratory production was used to ensure that each sample concentration had equal thickness, host polymer, and other possible variants. The dye developed by American Cyanamide is designated as Orange 205 and has the same chemical make up as that found in the commercial dye samples in polymethol methacrylate (PMMA) - namely 1-Phenylazo 2-Napthalenol. The Orange 205 was embedded in 1.6 mm thick polycarbonate at different concentrations to determine the effect of molecular density on absorption characteristics and threshold for reverse photosaturation. The dye was mixed with 0.1 milliliter polycarbonate in the following concentrations: 0.008%, 0.03%, 0.05%, 0.1%, and 0.15%. The commercially sold samples were found to have concentrations of 0.008% and 0.03%, respectively, in 12 mm PMMA.

Each sample was tested in a Perkin-Elmer Lambda 9 UV/VIS/NIR Spectrophotometer to obtain ground state absorption data from 200-1200 nm.. As expected, the results conformed to the hypothetical purpose of Orange 205 as an effective absorber of Argon-ion laser radiation. The dye transmitted less than 0.01% of the laser radiation at the Argon-Ion wavelengths when the concentration increased above 0.03%. The following page contains the optical density results on one of the samples.

EXPERIMENT SET-UP

At the onset of the set-up procedure it was decided that the laser and optic placement was to be limited to retain the most laser intensity as possible for the source of sample entry. The primary purpose was to have an accurate means of varying the laser beam power and to read that power before and after sample entry. The system would call for the directing of the laser beam through the sample at which point photo saturation or reverse photo saturation would occur. In either event the intensity difference of the beam after exiting from the sample was to be measured. The basic needs involved the following: Argon-ion laser, variable attenuation, polarization, spot size and intensity measurements, filtration, and calibration. A rough draft layout was developed to meet these needs as seen in figure 1.

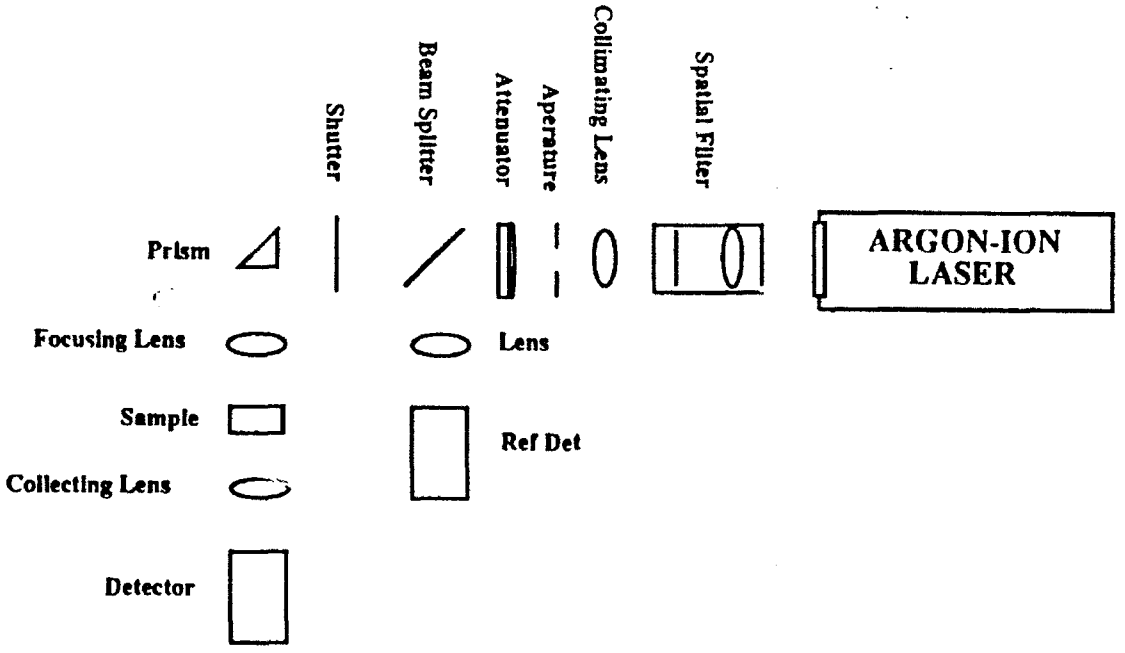


Figure 1.0

The laser beam originates in the argon-ion laser cavity. Once it exits, the beam will pass through a spacial filter. The spacial filter is composed of an objective lens and a pinhole size aperture. The objective focuses the beam size down to a point. The pinhole, which has a diameter of 25 microns, is brought to that focal point and apertures off any impurities surrounding the beam. The 'cleaned' beam leaves the spatial filter diverging. The diverging beam is then collected and collimated by a lens. The beam then passes through an aperture to rid diffraction that might have occurred from the pinhole. Once apertured, the beam will enter an attenuator to produce manual manipulation of beam intensity. The beam is then split in two by a beamsplitter. The lesser of the beam is focused by a lens into the reference detector. The greater of the beam continues down the path to the electronically controlled shutter. This shutter will allow the samples to reach ground state energy levels between laser exposures. When the shutter opens the beam is turned ninety

degrees to be focused by a lens into the sample. The beam passes through the sample and is collimated again by a lens that is prior to the second detector. The second detector, or sample detector will read the amount of energy that is to exit from the sample.

Variable Attenuation

Although the Argon-ion laser used has the means to increase and decrease power output, it is not easily adjusted nor is its output stable if the drive current to the inner-lying plasma tube changed. A continuous attenuation through three orders of magnitude was required for the experiment. Therefore, another method was to be found at which the laser could remain at a constant, stable output while the beam itself was reduced or increased in power. The most practical way to accomplish this was to use the combination of a half wave retarder and a beam splitting polarizer.

The half wave retarder used was an optic placed in a 360 degree rotational mount. A retarder is a birefringent material that rotates linearly polarized laser light to an angle ø, corresponding to the angle ø between the fast axis and the input linearly polarized laser. A birefringent material has two indices of refraction. The velocity of the wave will depend on the index of refraction, n according to $v = c/n$. For the smaller index, the velocity of the wave is along the fast axis, and for the larger index, the velocity of the wave is along the slow axis. A linearly polarized light wave at an arbitrary angle upon entering a birefringent material is decomposed into two orthogonal vectors called the ordinary and extraordinary waves that propagate along the fast and slow axis. Because the component along the fast axis travels faster, the e-wave and o-wave of the exiting wave will have a relative phase shift of 180°. Thus, the laser light may be polarized through any angle by rotating the angle of the fast axis.

Upon exiting the half-wave retarder, the laser light then enters the beam-splitting polarizer which transmits horizontally polarized light and reflects all other light. The amount transmitted depends upon the cosine of the angle between the laser light and the transmission axis.

When rotated, the retarder would rotate the polarization vector of the exiting vertically polarized beam. The beam would then enter the beamsplitting polarizer, whose polarizing properties allowed an accurate control of the transmitted and reflected intensities. These elements were aligned respectively with a RKP-575 pyroelectric detector connected to a Laser Precision RM6600 Universal Radiometer to capture the beam intensity exiting the beamsplitter. The laser was turned on and the output was measured as the retarder was rotated. The results proved satisfactory as seen in figure 2.

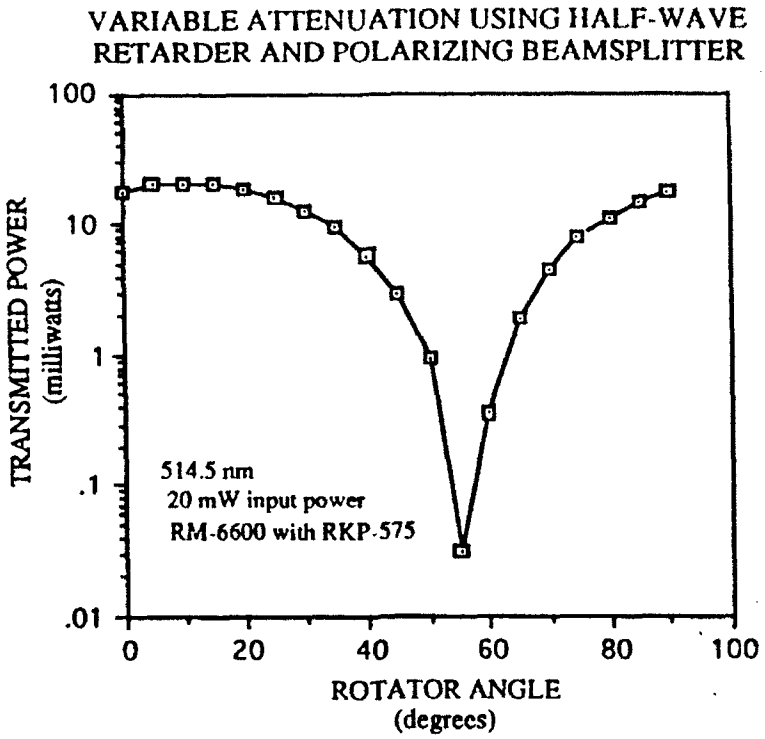


Figure 2.0

Divergence and Convergence near sample

After the turning prism (as seen in figure 1) a divergence of the beam was found to exist. This phenomenon is expected and was measured to determine to what degree it occurred. A Spiricon Laser Matrix Probe (pyroelectric array camera) was used to find the diameter of the beam between a distance of 0 and 500 cm away from the aperture. The distance in diameter at 500 cm proved that divergence did occur, creating a near field angle. The equation ϕ = d1-d2/D1-D2 (d= distance, D=diameter) was used to determine a beam divergence a near field angle of approximately 8 milliradians emerging from the aperture.

Once the 150 mm lens was placed after the second aperture, the convergence it produced was measured to find the distance at which the beam was a certain size (diameter) for sample placement. This procedure was virtually the same as the proceeding. The LASER MATRIX PROBE was positioned over a 300 mm distance that would cover the convergence and divergence of the beam emitted from the lens. Readings were taken every ten millimeters from the lens. An equation was constructed to determine the spot size vs. distance. The convergence formed a far field angle, which was determined with the same equation as used for the near field angle. This angle appeared to be approximately 52.1 milliradians. A graph of diameter of the beam in respect to distance from the 150 mm lens appears below.

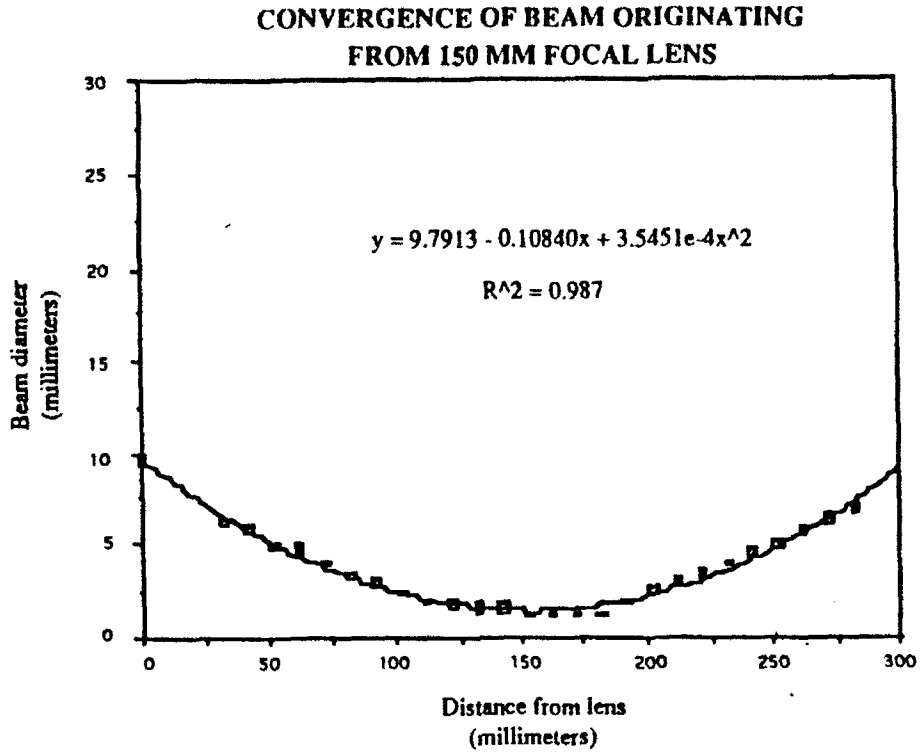


Figure 3.0

Calibration

The first RKP detector in the experiment layout served to measure the incident power that entered the sample. To do this accurately however, it was important to calibrate it to the exact power that left the lens prior to the sample location. This was important because of the nature of the beam to loose power between the first RKP and the location of the sample in addition to the fact that the first detector was only receiving a limited 4% of the laser radiation from the beamsplitter (see figure 1). The calibration was accomplished do to the ability of the RM6600 to divide the power readings by a calibration factor between 1 and .1. The calibration factor was found by the following means: A second RKP detector was placed at the point of sample entry immediately following the 150 mm focal lens (the location of sample entry). The laser was turned on and attenuated by the process mentioned over a scale of approximately 30 militates. The half wave retarder was rotated every two degrees at which point readings were taken from both detectors. These results were then graphed with the first detector (reference detector) used as the absyica and the second detector (power at sample) as the ordinate. The values graphed together formed a straight line, whose positive slope served as the calibration factor for the reference detector.

After the calibration of the reference detector was made, it was necessary to calibrate the detector that would detect the power leaving the sample. This calibration was made for the same reasons the first calibration was made. The second detector was placed at its permanent position following a collecting lens that collected the radiation the samples would transmit. The laser was then turned on and attenuated over the

same scale as used to calibrate the reference detector. Readings on both detectors were again taken every two rotational degrees. The results were then plotted with the second detector serving as the ordinate and the reference detector the absyica. The slope produced was entered into the RM6600 as the calibrating factor.

Final Set-up

The final experiment set-up appears in Figure 3. The attenuation devises (polarizing beamsplitter and half wave retarder) were positioned prior to the spatial filter to produced a higher peak energy level at sample location. A asbestos beam stop was added to contain the split beam at the polarizing beamsplitter. Line filters were mounted to the heads of each RKP detector. These filters allowed only vertically polarized light of the 514.4 wavelength to pass through them. The filters helped to effectively cancel out background noise. A second aperture was placed after the turning prism where it was found that destructive diffraction was present. The aperture cropped the edges of the beam allowing for a more uniform and clean beam to enter the sample. The two RKP detectors were connected to the RM-6600 which in turn was connected to a PC computer. The computer was to serve as an instrument of data gathering.

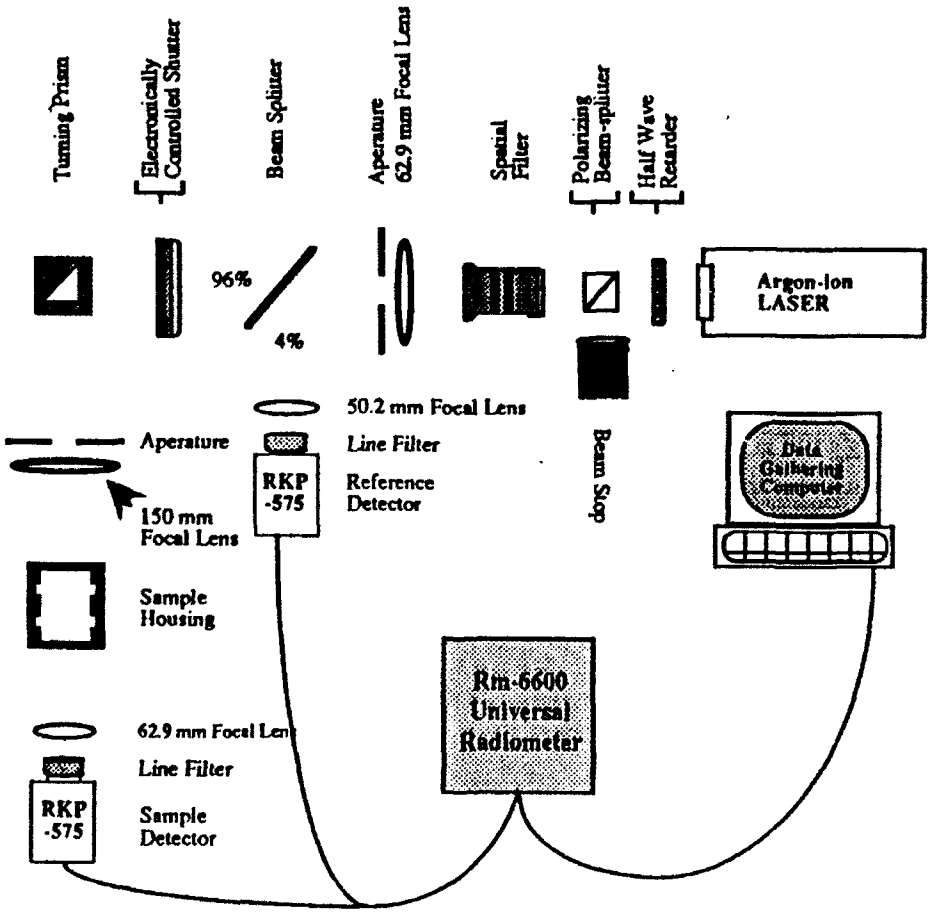
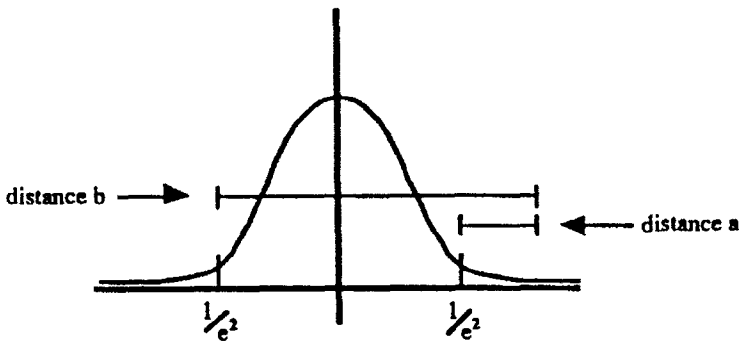
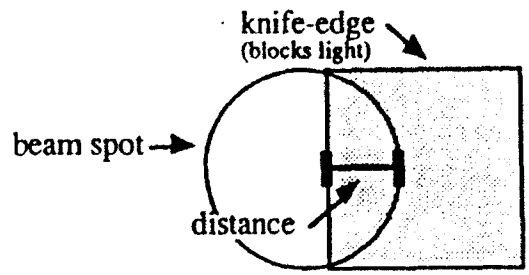


Figure 4.0



Gaussian profile



Knife-edge

figure 5.0

At each spot size location, the samples were subjected to 1mW, 10mW, 20mW, 30mW, 40mW, and 50mW of laser power. The combination of the two allowed for an intensity range from 0.00199 W/cm^2 to 636 W/cm^2. Data gathering began at the 8mm spot size. Each sample was subjected to the laser for each intensity listed above. Any transmittance under 10 microwatts was treated as background noise and not consitered vital to the results. Between intensities the samples were allowed to cool for a minimun of two minutes. This was to allow all orbitals effected in the transmission of the laser light to fall to ground state levels. Time was used instead of relocation of spot position to preserve a control condition.

Data

The program that collected the data also compiled it onto a floppy disk. The data was then transfered to a Macintosh Quadra 700 for plotting on Delta Graph Professional. The exiting laser from the sample was devided by the incident power to determin the percent of the incident laser light that was transmitted. The percent transmitted data was then plotted in relation to time. Individual graphs were made for the spot sizes of each concentration, with a curve for every beam intensity at that spot size (watts per squared centimeter). It was generaly found that the lower the intensity of the beam, the lower the percent of transmission of the total incident beam. Equally, the greater the intensity, the greater the percent transmission of the incident beam. The curves produced by the graphs failled to fit within the parameters of known equations, specifically the standard exponential equation and the standard percent transmition equation, $\%T = K(1-e^{t/t})$ Instead, it was believed that each curve actually comprised of three curves for three seperate and distinct phases that occured durring bleaching. In a few of the graphs that generally signified the greater intensities intresting curves formed. As the intensity increased and the level of the curve assended to higher transmission percents, a distinct hump in the curve appeared, after which a decline would occur before the curve resumed the course seen in previous graphs. The graph of the R&H, commercially produced sample at 2mm spot size shows both curves des :ussed above.

R&H Bleach, 2mm spot size

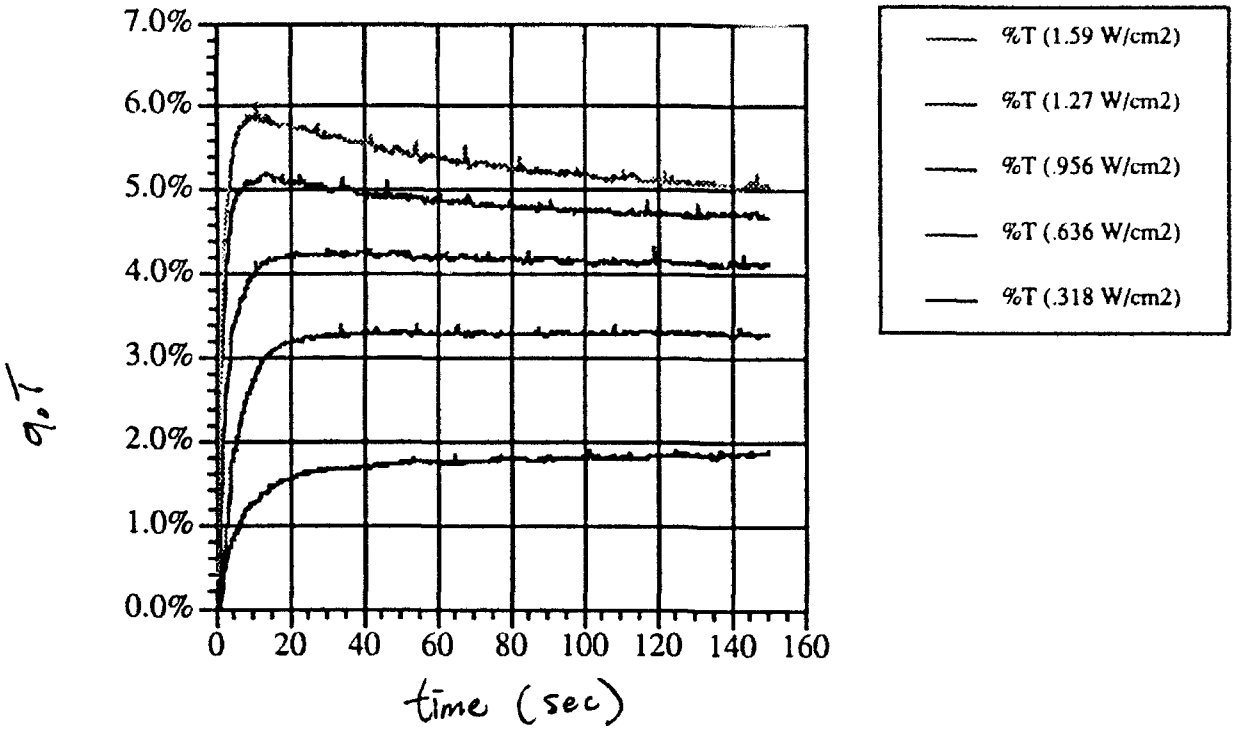


figure 6.0

The Dosimetry Program

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Final Report for:
Summer Research Program
Armstrong Laboratory

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Brooks Air Force Base, San Antonio, TX

August 1992

The Air Force Dosimetry Program

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Abstract

Radiation dosimetry is the technology of detecting radiation dose to human beings. The Air Force dosimetry program has been established to monitor the Air Force employees for any abnormal or overexposure to radiation as well as to minimize their liabilities. One specific group they monitor is pregnant female workers. I helped create the tracking board to insure records were reported in a timely fashion to base radiation safety officers (RSO) at 225 bases world wide. This board helps to protect all pregnant females in the Air Force that are employed in occurations in which exposures to ionizing radiation are a possibility.

The Air Force Dosimetry Program

Jennifer C. Gonzales

INTRODUCTION

In recent years we have become more concerned with the effects of radiation on people, this has resulted from an awareness of the hazards that accompany exposures to ionizing radiation. The dosimetry program is on hand to determine the dose to which a person has been exposed. There are four different kinds of radiation that the dosimetry program is most concerned with: alpha, beta, gamma, and neutron radiation. Health Physicists evaluate radiation hazards and recommend protective measures. They study the different structures and effects there are of radiation. The dosimetry program is very important because they have instruments that will sufficiently monitor radiation levels that the workers are exposed to in their work area. The Air Force dosimetry program is approved through the National Voluntary Laboratory Accreditation Program. Brooks Air Force Base is responsible for monitoring all Air Force employees. The Air Force uses thermoluminescent dosimeters for their monitoring program, and they provide the dosimetry program through out all Air Force commands.

METHODOLOGY

According to Health Physics: The Radiation Protection Journal

Bohm and Ambrosi (1985) identified the following seven objectives for personnel dosimeters: providing information for estimating worker exposure for regulatory compliance; having a very wide dynamic rang covering both minimal and life threatening dose ranges in units relevant for postaccident medical care; indicating the types and energies of the radiations; providing work place environmental information; providing data for ALARA program coordinators; providing data on the adequacy of work place designs, work procedures, and personnel training; and providing data for future epidemiological studies, risk and benefit analysis, and medical and legal purposes.

DISCUSSION OF PROBLEM

Radiation overexposure affects all of the organs and systems of the body but, not all of them are as sensitive to radiation so the amount of damage varies. There are some signs that you will able to detect if you have received an overexposure of radiation: nausea, vomiting, malaise, fatigue, increased temperature, or blood changes. You can also receive syndromes like hemopoietic which effects the bone marrow, gastrointestinal which effects the scale of intestinal epithelium, and the central nervous system which effects your main organs. With the effects of these syndromes you will live no longer than two years. You can also receive changes in pigmentation and epilation with a much higher dose of radiation. They may also cause blistering, necrosis, and cancer, leukemia, cataracts, genetic effects, and shortening of life span.

RESULTS

Thermoluminescent dosimeters are being used to detect the amount of radiation that their employees receive in their work area. The Air Force provides their employees with these dosimeter badges to protect them from over-exposure to radiation. Occupations that are being exposed to high radiation as are medical x-ray thechnicians, dental and veterinary x-ray thechnicians, medical users of radioisotopes, industrial users of radioisotopes (other than x-rays), industrial x-ray thechnicians, radar operators, reactor operators, scientists, engineers, doctors, and physicists. These dosimeter badges contains two compounds, calcium sulfate and lithium borate. These compounds are able to record the amount of radiation exposure of the individual. Neutron exposure can also be recorded. The neutron monitoring dosimeters contain a cadmium insert on the front side to distinguish different types of radiation. The dosimetry program uses two of the several units to measure radiation which are RAD and Roentgen. RAD means radiation absorbed dose measures the radiation that is being absorbed by the body tissues, and the Roentgen is used to measure the radiation exposure in the air. To test the exposure of the thermoluminescent dosimeter badges they are exposed to radiation sources that are found in the calibration facility on base. These radiation source are gamma radiation, Cesium 137, and x-rays. There is a proper way to wear dosimeters badges, there is one on your collar that is worn on the out side of protective covering it tells how much radiation exposure had gone into your head and lens of the eye. Another one

is a whole body and extremity you wear it underneath any protective covering. It tells you how much your body is exposed to radiation. There is also an annual dose limits they are as follows: for deep dose equivalent plus committed dose equivalent for any organ/tissue is 50 REM, eye dose equivalent 15 REM, shallow dose equivalent 50 REM, extremity dose equivalent 50 REM, and for the total effective dose equivalent is 5 REM.

CONCLUSION

In conclusion, this is a description of the Air Force dosimetry program. The biological effects of ionizing radiation were also addressed.

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THE USE OF COMPUTER TOOLS AND SEMANTIC NETWORKS FOR KNOWLEDGE ACQUISITION

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THE USE OF COMPUTER TOOLS AND SEMANTIC NETWORKS FOR KNOWLEDGE ACQUISITION

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Abstract

Various tools exist for the aquisition and organization of knowledge, including a process known as concept mapping. Concept mapping was used to organize and interpret data concerning human factors engineering, electronic interfaces, and collaborative processes. Two different computer tools were used to organize and analyze the composite data. Because one tool was still in the design phase, researchers also served as troubleshooters and constructed a user's guide for the tool.

THE USE OF COMPUTER TOOLS AND SEMANTIC NETWORKS FOR KNOWLEDGE ACQUISTION

Margaret J. Hahn
Michael S. Nancarrow

INTRODUCTION

Human Factors Engineering (HFE) is concerned primarily with designing machines and electronics so that they work more efficiently with the user. HFE is crucial, for example, in designing cockpits in fighter planes so that the pilot can see and use all of the instruments and controls. Concept Mapping is a method of acquiring knowledge and spatially organizing the data acquired. A semantic network, or concept map, is a graphic representation of information composed of circles and lines, with each circle containing a concept, and each line containing a relationship linking that concept to another. The map becomes network of relationships connecting concepts (See Appendix A). These maps, representing expert knowledge, can be analyzed with unique computer software to organize and distill pertinent information. Student work involved application of this methodology.

METHODOLOGY

The map is generated during the interview on a blackboard or whiteboard through an interactive interview with a knowledge domain expert. The domain expert sees th map as it is being generated from his statements, so he can correct mistakes or misinterpretations immediately, unlike a normal interview with the interviewer simply taking notes on a pad, making his own interpretations of what the domain expert intended to say. This promotes accuracy of the information gathered and spurs the expert's memory and thoughts, since he sees his ideas on the board. After the interview is complete, the map is copied onto paper from the board and is then entered into one or both computer tools. With the first tool, appropriately called Concept Mapping Tool, entry is a simple matter of typing in the "triples" or a set of concept-relationship-concept. After all of the triples have been entered, the computer generates a concept map. Unfortunately, the user must rearrange the concept-circles, called nodes, to untangle the connecting lines before the map is readable. Entry on the second tool, Concept Interpreter, is a more involved process. The user must place each node and type in the concept on the screen. This process takes a little longer than using Concept Mapping Tool, but the

Concept Interpreter has a sophisticated data base interpreter and analysis functions that generate an information category matrix across several maps, increasing the utility of the entire mapping exercise. The matrices are used, among other purposes, for identifying various areas of data, such as visual-related responses. These areas can be color coded onto the map by hand, making the map easier to read. On the mapping of the human factors engineering project, information was presented in hierarchical-numeric form and entered into map form with Concept Interpreter to make it more presentable, since it is hard to follow hierarchical numbers through five layers. The initial data were presented on forty-two double sided pages. The maps finally occupied thirty-eight pages in laidout format, but the maps also made more sense.

The electronic interface data was first presented as raw survey responses in electronic-mail format. After transferring them to a word processor on a Macintosh, the responses were cut-and-pasted into response areas such as Office Tools/Problems and Communication Tools/Successes (Appendix B). The response areas were printed, taking forty-three pages. The responses were then mapped on Concept Interpreter and matricies built for analysis. The Division Advisory Group, who commissioned the work, was very pleased with the results.

Concept Mapping Tool was used during several concept mapping sessions where the triples were typed into a MacWrite II text file throughout each interview. From the text file Concept Mapping Tool formed a concept map that had to be untangled. During the interview with the domain expert, one person would draw the concept map onto a whiteboard. Another person would draw the map onto paper, and another would type the triples. Several others would also be involved in the interview process, probing the domain expert. These sessions would generally last an hour. However, some sessions lasted two-and-a-half to three hours.

Writing a user's guide involved the process of becoming familiar with Concept Interpreter. This was also an opportunity to serve as troubleshooters for the software. Input provided will be published by AL/CFHI in a guide describing the use and analysis of concept mapping in knowledge acquisition and information management.

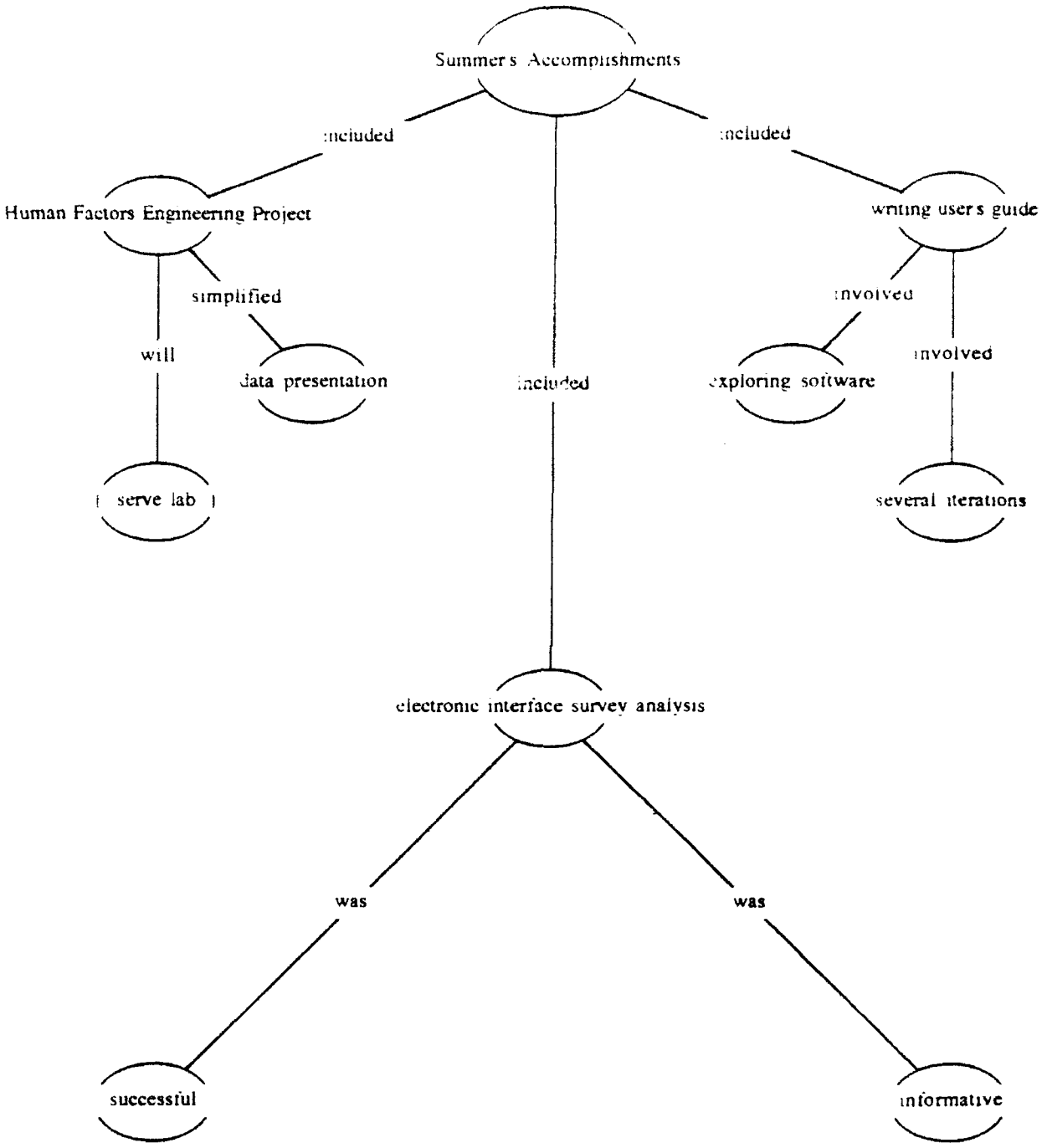
RESULTS

Because the projects above are not quantitative in nature, it is difficult to attribute quantitative results to them. However, some conclusions can be drawn from some of the projects. The

electronic interface project resulted in successful identification of the problem areas in the interface, primarily lack of standardization and the unfriendliness of the system. As noted above, the Division Advisory Group was pleased with the results. The user's guide is in its final form, ready for publication when the software is ready, except for a preface explaining concept mapping (Appendix C).

Appendix A

Concept Map: Semantic Networks and Knowledge Acquisition


Summers Accomplishments
included
included
Human Factors Engineering Project
writing users guide
simplified
involved
will
data presentation
included
exploring software
involved
serve lab
several iterations
electronic interface survey analysis
was
was
successful
informative

Appendix B

Sample Electronic Interface Survey

Division Advisory Group Survey
Internal Information Management and Data Fusion

Recently, Ken Boff created a Division Advisory Group (DAG). This ad hoc advisory group is charged with investigating how information is used, managed and integrated within the division and with suggesting short-term, mid-range, and long-term recommendations for support and improvement. The impetus for this effort came from the many frustrations and problems expressed informally by members of the division in handling, organizing, and integrating information. Frequently information that exists electronically cannot be easily combined because of differences in hardware, software, format, etc. Too often we resort to needless data re-entry, reformatting, photocopying, and paper proliferation. Because the successful functioning of the division depends on people working in collaboration, exchanging and integrating information, communication problems such as these undermine productivity and cause needless aggravation. It is therefore important to better understand the nature of these kinds of problems and work toward their solution.

We feel that it is imperative to get comments from the people in the division as to the problems that they are having and improvements that they would like to see implemented in the area of information management. Your involvement in this effort is crucial in order for us to be successful in identifying ways to improve the system and to help you do your job. In this case we are from the government and we really do want to help you. Although all input is welcome, we would especially appreciate your views as they relate to six areas:

1. **Office Tools** - General tools for individually handling information. Specifically, these may include word processors, spreadsheets, graphics, personal databases, calendars, printer, etc.

2. **Communication Devices** - Tools used to communicate with co-workers and collaborators both within and outside the division. Specifically, these may include e-mail, FAX, photo-copier, telephone, VAX-Phone, file transfer, modems, graphics, voice mail, teleconference, etc.

3. **Laboratory Tools** - Tools used to conduct research such as data collection devices, specialized hardware and software, software development, graphics, expert systems, computer aids, etc.

4. **Distributive Data Sharing** - Tools used for distributing information widely such as bulletin boards, system messages, databases, calendars, networks, news, etc.

5. **Archive/Data Storage** - Tools used for data backup and storage such as tape backup, data compression and decompression software, etc.

6. **Other** - Tools and procedures not defined above.

As you make your open-ended comments in these areas, please try to provide comments which indicate:

(a) what tools you use and how frequently you use them,
(b) what frustrations or problems you have experienced,
(c) what successes or lessons you have learned,
(d) what future needs you anticipate, and
(e) whatever else you want to tell us, especially if you have suggestions regarding hardware, software etc that you are familiar with that might be useful in this area.

Please feel free to respond selectively - that is, we would rather that you take the time to comment on only one or two areas of particular relevance to you, than for you not respond at all! When possible, please try to outline your responses by combining the NUMBERED AREAS (1 to 6) with the COMMENT TYPE (letters a to e). For example:

2b. (Communication frustration or problem): "I hate it when I need to send a beautifully formatted MacWrite file over e-mail and it becomes an ugly, unformatted ASCII file."

For those of you that would like to participate further in this process please provide your name an phone number. We would to interview people to better understand their inputs in this area and will be using some of the interview techniques developed by CFHD and CFHI.

Name:_____ Phone:_____

Finally, we would prefer it if you would PLEASE RETURN YOUR RESPONSES TO US ELECTRONICALLY USING E-MAIL to "info_dag". (We will accept hard copy if you prefer c/o Randy Yates CFHD Rm 103-D bldg 248.) Please provide inputs not later than 3 July 1992.

Thank you very much for your input,

Division Advisory Group for Internal Information Management and Data Fusion:

Randy Yates (Chairman), Gloria Calhoun, Bob Centers, Marie Gomes, Bill Marsnak, Mike McNeese, Bob Osgood, and Cliff Brown (Resource Person)

1. OFFICE TOOLS: These are the tools I use (listed by frequency of use):

Word Processor:	MacWrite, EDT-Runoff
Spreadsheet:	Excel
Graphics:	Canvas
Presentation:	PowerPoint
Database:	HyperCard, FileMaker
Program Management:	MacProject

NICE TO HAVE UTILITIES:
Spell Checkers
Synonym Finder: Word Plus
Word Finder: On-Location
VAX FINGER
VAX JOCUS

COMMENTS: In and of themselves, these office tools are fine. (Any of them have problems, but these are probably beyond the scope of the DAG.) The biggest problems arises when I try to share the data with someone else because of incompatible file formats.

I had been a frequent user of the VAX EDT in keypad mode. One helpful hint, I found was to tape the EDT keypad commands on each of the keys. This is especially helpful now that I use EDT infrequently. If I have much VAX typing to be done, I create text using my Mac word processor, cut/copy it, and then paste it into VAX. Almost by definition, any word processor is better to use than an editor.

PowerPoint is outdated as a presentation tool. It needs better graphics capability and the ability to add transitions between slides.

2. COMMUNICATION DEVICES: These are the comm devices I use (listed by frequency of use):

Telephone
Photocopier
E-mail
Fax
File Transfer: Mac240 (Kermit, X-modem, Y-modem)
Speaker phone conference calls
Multi-line telephone conference calls

COMMENTS: E-mail for short messages is fine, but I would really like to able to send a short identifying note with a file (text and/or binary) attached to the note. The file should maintain it own identify so that a receiving computer knows what application created the file.

The command line mode for mail is difficult. It makes me remember all the little nuances and rarely used commands, flags, parameters, etc. If it wasn't for the example section of most of the VAX help files, I could never to anything but use the standard issue VAX commands.

It would be nice if the e-mail message could be saved to a format besides ASCII.

It is annoying to be in the process of sending a message only to discover that there's someone else whom you would like to send a copy. You

should be able, while in the midst of sending a message to change or add names to either the primary recipients or CC recipients.

It is annoying to being forced to exit mail before I can print a message.

VAX-phone is the most annoying utility in existence. If someone tries phoning me, by the time I can figure out how to answer the phone, the caller has hung-up. I keep VAX-phone disabled.

Likewise the SEND command is annoying. It breaks into my on-screen work, breaking my train-of-thought. The worst part, however, is it demands that I process it now, since it is transient data. When that screen is gone, there is no trace of the message. At least with mail, I can process it when I choose. Sometimes Send is what you actually what to use - time critical messages which must be processed immediately, but more often than not, this is not the case.

For items already in the computer, it seems a waste of time and supplies to have to print it out and then fax it. I should be able to fax it directly from the computer as easily as selecting a printer.

The primary reason I use File Transfer is to receive a large e-mail text file. (To send one, I typically paste text into the VAX editor.) A frequent problem is setting up the transfer. I never know which machine to start first - is it sender first or receiver first or is it Mac first or VAX first. Typically, I make the wrong choice and have to wait for a time-out error to try again.

3. LABORATORY TOOLS

SuperCard

4. DISTRIBUTIVE DATA SHARING

Bulletin Boards: I only use the general division & branch BBs
Calendar: VAX CAL & Macintosh Smart Alarms & Appointments by Jam
Networks: DecNet and AppleTalk (AlisaTerminal, AppleShare & Public)

COMMENTS: The bulletin boards are a great way of distributing messages. By biggest complain with them is getting a hardcopy if I need it. Typically, I only use the bulletin boards when I first log-on and see the new bulletins that have been added to board. If I see something that I want a hardcopy of, I can not just select PRINT at that time. I'm forced to remember which board I'm in, go through the rest of the bulletins, go back into BULL, select the desired board, find the bulletin, and finally can I finally print it.

The Calendar feature is great. I like being able to see if conference rooms are available and being able to schedule annual leave using the branch calendar. But I really dislike the Calendar user interface. When I'm looking at a particular month, why can't I just enter text. Also, it's not uncommon to hit a wrong key and get completely locked-up in some obscure mode. I dislike not being able to schedule the conference rooms myself.

AppleShare is nice to be able to log-onto the VAX, but it is really slow in doing file transfers. This is why I routinely use Kermit to transfer files instead of AppleShare, even though Appleshare lets me drag files into folders just as I'm accustomed to doing on the Mac.

The public folder is great in what it provides - a way of transferring Mac files that are immediately usable without having to do a format change. My major problem is that it's read only. I can't send a file to someone. They have to read it from me.

5. ARCHIVE / DATA STORAGE

6. OTHER

Network Bandwidth: The current bandwidth is sufficient for passing small messages. For future use it needs to be much, much faster it we want to consider voice mail or video mail.

Appendix C

User's Guide

Creating concept maps is a simple task with "Interpreting Cognitive Maps." The software does all of the hard work for the user. Even the most complex concept maps can be created by following a few simple procedures. This manual assumes a basic understanding of the operation of the Macintosh Computer. Refer to the Macintosh System Software User's Guide and the Owner's Guide for supplemental information.

Section 1.0 Terms and Definitions

This manual uses many terms that have specific meanings within the context of the software. These are delineated herein.

1. Pointer Tool: The pointer tool is represented by the Macintosh arrow. When the Pointer is active, clicking will box text or nodes, allowing them to be moved. It is also the tool to use when selecting a certain object to be manipulated by the software.
2. Browse Tool: The Browse tool is represented by a small hand. When the Browse Tool is active, contact with text will cause the tool to become the standard Macintosh text insertion cursor. Clicking as the insertion cursor will allow entry, alteration, or deletion of text.

Note The software genarally attempts to provide the user with the correct tool. The Browse tool can be changed to the Pointer by clicking on an object. The Pointer automatically returns to Browse mode after it is used. If you desire to change tools, simply select the appropriate tool from Concept Map.

3. Highlight: Highlight means to use the Browse Tool to highlight text such that the background becomes dark and the text white. Highlighting is a necessary to delete strings of text.
4. Box: Box means to use the Pointer Tool to select an object such that four small black squares appear at the corners of an imaginary rectangle surrounding the object. Boxing is necessary for moving objects and selecting nodes or links for deletion or for the creation of new nodes and links.
5. Node: A node is an oval containing a concept.
6. Link: A link is a line joining two nodes with a relationsip overwritten.
7. Triple: A triple is a set of "Concept-Relationship-Concept" or "Node-Link-Node"

Section 2.0 Creating a New Map

1. Select a new map from **File**.

This should display a large oval that says "Node 1," a line that says "Link 1," and a smaller oval that says "Node 2."

2. Name the Map.
3. Click on the text to write your own node and link labels.

The large oval is for the primary subject concept, the line for the relationship, and the smaller oval for the secondary concept. It is likely that you will want to have more than one node off of the primary node. In order to do this, two things must be done: add a node and move a node.

Section 2.1: Adding Nodes

Additional nodes can be created easily with the Add Destination function under the **Concept Map** heading or the <Command-D> keystrokes.

1. Box the source node oval with the Pointer Tool.
2. Press <Command-D> or select "Add Destination" from **Concept Map**.
3. Label the node and link just as in section 2.0.

Note: It is critical that you do not use the exact same word or phrase to describe more than one node.

Section 2.2: Moving Nodes

Nodes can be moved easily with the mouse. Since new nodes appear in a standard position, it is imperative to move nodes to new positions if more than one destination node is desired. Also, it is often desirable, for space considerations, to move a node to keep the map readable.

1. Box the desired node with the mouse.
2. Hold down the mouse button and drag the node to the desired location.
3. *Note*: Be sure that the destination node is lower on the screen than the source node. This convention makes the map more readable by providing a "Top to Bottom" organization of the concept map.

The link and text should realign into the new position, but it is sometimes necessary to **Refresh** the screen (See Section 2.9)

Section 2.2.1: Moving Multiple Nodes

Multiple nodes can be moved easily with the mouse, as well. This easier than to move a set of node one at a time.

1. Box the first node with the mouse.
2. Hold the <SHIFT> and click on the desired nodes..
3. Hold down the mouse button and drag one node to the desired position, and the other nodes will follow in relative position.

Note: When moving groups of nodes, the groups can move only along the main axes of the screen. No diagonal movement is possible.

Section 2.3: Additional Links

Additional links between existing nodes can be made by using the Add Link command under **Concept Maps**.

1. Box the destination and source nodes.
2. Press <Command-L> or select Additional Link from **Concept Map** to add link.
3. Label the link as in section 2.0

Section 2.4: Key Concepts

Certain nodes can be designated as "Key Concepts" to increase map readability and are noted as such in the data base. (See Section 3.5)

1. With the browse tool, point to the desired node, hold down <OPTION>, and click.

The node should increase in size to indicate that node as a "Key Concept."

Section 2.5: Deleting Nodes

Deletion of unwanted nodes can be accomplished easily with several commands.

1. Box the node to be deleted.
3. Press <Command-X> OR
4. Press <DELETE> OR
5. Select "Delete Destination" from **Concept Map**.

Section 2.6: Deleting Links

Deletion of unwanted links can be accomplished two ways.

1. Box the node at each end of the link.
2. Select "Delete Link" from **Concept Map**.

Section 2.7: The "Find" Command

The "Find" command can be used to find words or phrases appearing in links and/or nodes. The computer will highlight each occurrence of the word or phrase, then ask if it should continue searching.

1. Press <Command-F> OR
2. Select "Find" from **Concept Map**.
3. Type the desired word or words.
4. Follow the prompts.

Section 2.8: The "Go To" Command

The "Go To" command can be used to go to a specific location on the screen designated by a coordinate. This can be accomplished two ways.

1. Press <Command-G> OR
2. Select "Go To" from **Concept Map**.
3. Type the desired coordinate.
4. Follow the prompts.

Section 2.9: Refreshing the Screen

The screen can be refreshed whenever words, lines, or ovals appear displaced from the appropriate position. Refreshing will translate the errant objects to the proper position. This can be accomplished two ways.

1. Press <Command-R> OR
2. Select "Refresh Map" from **Concept Map**.

However, this is rather slow. If only a few items are misplaced, simply move the nodes involved one at a time.

Section 2.10: Saving the Map

The concept map can be saved on your disk.

1. Select "Save Project" under File.

Section 2.11: Resizing the Map

Most maps will be far too large to fit on one page. Fortunately, it is possible to adjust the size of the map.

1. Select "Map Size" from **Edit**.
2. Select the appropriate size, 1x1, 2x2, 4x4.

Section 2.12 Opening Maps

In most cases, you will want to close the map and return to it at a later time. This is done just like a word processing file.

1. After boot, select "Open Map" from **File**.
2. Select the desired map or maps.
3. Follow the prompts.

Section 2.13 Deleting Maps

Eventually, even the best map will outlive its utility. Deleting maps is easily accomplished.

1. Select "Delete Maps" from **Edit**.
2. Select the maps to be deleted.
3. Follow the prompts.

Section 3.0: The Interpreter

Upon completion of the concept map, a data base can be built from the map to help organize and interpret the information contained in the map.

Section 3.1: The Data Base

Section 3.11: Building the Data Base

Building a data base allows the program to perform its more sophisticated functions of analysis. It is necessary to build a data base before continuing further.

1. Select "Build Data Base" from **Interpreter**

Section 3.12 Viewing the Data Base

It may be useful to view the completed data base.

2. Select "Concept Data Base" from **View**

It is possible to save the data base into a text file for use with a word processor or other application.

3. Click on "Save" while viewing.

It is also possible to print the data base

4. Click on "Print" while viewing.

Section 3.2: Triples

It is possible to save the triples into a tab-delimited text file for use with a word processor or other application.

1. Select "Save Triples (Text)" from **Interpreter**

2. Accept or type in a new name for the file, then click on "OK."

Section 3.3: Concept Nodes

The program will also display the nodes in alphabetical order, listing the number and field location for each node label.

1. Select "Concept Nodes" from **View**.

While viewing, the nodes can be saved to a text file or printed.

2. Select "Save."
3. Select "Print."

Section 3.4: Outline

A more readable and useful form of the data base can be provided in the form of an outline. This outline can be used a guide for other writings or analyses. It is necessary, however, to build a data base before the outline can be created.

1. Select "Build Outline" from **Interpreter**.

It is possible to save the outline onto a text file for use with a word processor or other application.

2. Select "Save Outline (Text)" from **Interpreter**.

The outline can also be viewed.

3. Select "Outline" from **View**.

While viewing the outline, it can be saved or printed.

4. Select "Save."
5. Select "Print."

Section 3.5: Viewing Saved Data

Viewing a data base or outline previously saved does not require a reconstruction of the data base or outline.

1. Select "View Saved Data" from **Interpreter**.

At the top of the screen, **View** will be highlighted. Select the desired choice from **View**.

Section 4.0: Using a Matrix for Analysis

Building a matrix allows you to view concepts in an organized manner across multiple concept maps. The program also allows you to define categories and key words for analyzing the information content in the maps.

Section 4.1: Defining Categories and Key Words

The matrix is comprised of categories that are defined in terms of key words. These categories are used to classify relationships between concepts, for example, spatial orientation. Key words to define spatial orientation include up, down, left, right, position, etc. The asterisks may be placed as a suffix to include all forms of the word.

Commas separate the different key words. Semi-colons serve to limit the relationship to the single word. For example, "is;" would recognize "is" as a valid member, but would not recognize "is included" or other phrases including "is...."

1. Select "Edit key words" from **Analysis**.
2. Click the area below the title bar.

3. Type the desired category.
4. Click the enclosed area below to define the category.
5. Press the right arrow to procede to the next category.

Section 4.2: Clearing a Matrix

The program automatically saves the matrix, so before making a new one, it is necessary to clear the previous matrix.

1. Select "Clear MATRIX" from **Analysis**.

Section 4.3: Building a Matrix

Upon completion of defining the necesssary relationship concepts, a matrix can be built to organize the data base. Several maps can be displayed on the matrix at once.

1. Build a Data Base. (See section 2.1)
3. Select "Build MATRIX" from **Analysis**.

The matrix will display a grid of the different map names and the user-created categories.

Section 4.4: Using the Matrix

This grid will display occurrences of each type of relationship. A dot indicates one occurrence, while a dot with a circle indicates more than one occurrence. Clicking on a dot will display a list of the triples that contain a key word for that category and list their map number and field identification number. Clicking on a category name will display the key words for that category and allows the user to alter the key words.

Section 4.5: Printing the Matrix

A hard copy of the matrix can be very useful. Fortunately, the matrix can be printed.

1. Select "Print MATRIX" from **Analysis**.

Section 5.0 Identified Problems and Limitations

1. <ESC> can be used to delete a boxed node.
2. <Option-T> can be used to delete a selected link.
3. Holding <shift> while selecting a menu item or object, or using a command stroke, will allow access to the script editor.
4. Cannot stop a script in process.
5. Cannot Copy text between fields in key words.
6. DO NOT delete the space provided for a link label with the Pointer tool.
7. DO NOT use the same exact label in more than one node.

THE DEVELOPMENT OF INTELLIGENT TUTORING SYSTEM

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Final Report for:
Summer Research Program
Armstrong Laboratory

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THE DEVELOPMENT OF INTELLIGENT TUTORING SYSTEMS

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BRACKENRIDGE HIGH SCHOOL

ABSTRACT

During my eight week tour as a summer apprentice at Armstrong Laboratory I was able to take part in the Fundamental Skills Training (FST) project which is designed to transfer government developed technology to education and industry. Through this project I was able to gain a better knowledge and understanding of Artificial Intelligence (AI), the idea this project is based upon, and Intelligent Tutoring Systems (ITS), the devices used in this project. While researching these fields I was also able to become more experienced in areas related to and a part of the FST project such as Computer Based Instruction, software design and development, computer graphics, and Virtual Reality Systems.

THE DEVELOPMENT OF INTELLIGENT TUTORING SYSTEMS

BRYAN HAVEL

INTRODUCTION

Today there is a growing need among schools of a new approach or method of teaching which will alter, modify, and enhance our educational system of the past. As an answer to this, computers have become societies new technological change, our emergence into the future which already has begun to effect business, industry, and our daily lives. Therefore, the obvious change becomes to integrate computers into the learning and instructional environment in hopes that it will also make great advancements there.

To initiate this change the United States Air Force (USAF) has commissioned the Armstrong Laboratory/Human Resources Training & Intelligence Branch to begin a long term research project in Fundamental Skills Training aimed to design, develop, test, and evaluate three Intelligent Tutoring Systems in mathematics, writing, and science in area high schools over the next four years.

HISTORY

The revolutionary potential of computers for instructional use has been evident since the first years of common computer usage. However, the vision of what is possible, even from the most visionary standpoint, has grown rapidly and constantly. Research

is being conducted at an accelerated pace in laboratories all over the world and their many examples of various projects provide a vivid demonstration of the vitality of this field. This research represents the best and in most cases the first implementations of many diverse frameworks and foundations which have emerged from leading academic and industrial institutions. This demonstrates the recent and vigorous flourishing this technology has experienced and shows why work done in ITS over the past decade is suddenly finding its way, in great demand, into many real-life venues.

ANATOMY

The evolution from computer-assisted instruction to ITS comes from the passing of three tests of intelligence (Burns & Capps 1988). First, the subject matter, or domain, must be understood by the computer system well enough for the embedded expert to draw inferences or solve problems in the domain. Second, the system must be able to deduce a learner's approximation of that knowledge. Third, the tutorial strategy must be intelligent so that the instructor can implement strategies to reduce the difference between the expert and student performance. Therefore, we find at the foundation of an ITS three special kinds of knowledge and problem solving expertise which are programmed into one complex instructional system. These knowledge foundations-expert knowledge, student diagnostic knowledge, and instructional or curricular knowledge combined with the instructional environment

and the human-computer interface form the anatomy of an Intelligent Tutoring System.

EXPERT MODULE

The expert module is the part of the tutor which contains the domain knowledge. The module must have an abundance of specific and detailed knowledge which comes from people who have years of experience and are considered experts in their particular field. Complex domains often require a vast amount of knowledge from a variety of fields which often makes the expert module the most demanding and time-consuming chore in developing an ITS. In the development of HRTI's three FST tutors, this expert module would be designed from the knowledge of the math, English, and science high school teachers who would be the domain experts.

STUDENT DIAGNOSTIC MODULE

The student diagnostic module diagnoses the student's current understanding of the subject matter allows the system to use this understanding to adapt the instruction to the student's individual needs. The output from the student diagnostic module can be used for a variety of purposes including advancing through selected curriculum which is already known by the student, emphasizing new materials, and adapting sets of explanations which will better suit the individual's needs. In the FST tutors this process could be used to asses the student's abilities to understand simple or complex problems and help to gain a better judgement of the

student's level of ability.

INSTRUCTIONAL AND CURRICULAR MODULE

The instructional and curricular module takes the assessment of the student diagnostic test and plans a lesson which is appropriate to the student's plateau of knowledge and understanding and from this presents a strategy which will enable the student to gain the knowledge he or she lacks. In the FST project this would allow the tutor to pinpoint the student's deficiencies and prepare an assignment which will address those needs.

INSTRUCTIONAL ENVIRONMENT

The instructional environment is the facility which encompasses all that the student is doing. this includes the situations, activities, tools, and surroundings provided by the system to induce learning. This environment should not only conform to what is being learned, but also enhance it. It should use activities which will combine the student's prior knowledge with new information and experiences from which the student can construct new knowledge. The environment should also connect in-school and outside-school knowledge while emphasizing education as a life-long pursuit. With these principles adhered to, the computer instructional environments become self-contained worlds which can change and modify learning to new levels. In the FST project, this environment includes a traditional classroom setting with an individual computer workplace for each student. The

computers themselves do not only contain the standard tutors, but also various tools, games, journals, and graphics which give the environment a more personalized and comfortable setting.

HUMAN-COMPUTER INTERFACE

The human-computer interface is the communication between the learner and the computer system. This interface is critical because if it is poorly designed, the student will waste valuable instructional time merely trying to work the computer. In the FST tutors students can directly manipulate commands and icons to move them through the program. In most cases the time spent acquainting yourself with this method of human-computer interaction is quite minimal and once you are familiarized with the system this interaction time becomes almost unnoticeable.

TYPES OF TUTORS

The Human Resources Training and Intelligence Branch is in the process of developing, implementing, and evaluating three tutors in mathematics, writing, and science to be used in area high schools over the next four years. The first tutor, a Pre-algebra word problem tutor, is unique in the fact that it will not only teach individuals how to solve specific word problems, but also teach more general problem solving strategies that can be applied in other contexts (Steuk & Bellows 1992). The second tutor will assist in the development of reading and writing skills by guiding the students through various phases of reading, prewriting,

drafting, revising, and editing of written materials. The third tutor, a biology tutor, will help students to obtain, organize, and understand an abundant amount of information about the various creatures, principles, and processes in biological studies.

IMPLEMENTATION OF TUTORS

The HRTI branch projected four-year schedule is designed to develop and test each tutor separately, beginning with the math tutor, followed by the writing tutor, and ending with science tutor. The math tutor has already passed developmental stages and was recently tested in a single classroom setting at a local high school over the past year. Its results show the tutor increasing learning and enhancing the abilities of the students to solve word problems in a more effective manner. To gain a more in depth analysis on a wide scale, the tutor will be involved in numerous classroom settings in several schools next year. The writing tutor is currently in the late stages of its developmental phase and it is projected to be field-tested this coming school year. The science tutor is presently in a designing phase and will most likely be tested the year after next if plans go as scheduled.

ITS GOALS

As stated before, the primary goal of the FST tutors is to integrate government developed technology into the educational system in hopes of further advancing the learning process. At the Armstrong Lab this goal is substantially important, but not solely

concentrated upon. With the development, implementation, and evaluation of the Pre-algebra word problem tutor completed, it has been found that not only were the pre-conceived targets and goals achieved,but also numerous new abilities and skills. At a general level the tutor helped to form skills in defining the problem, representing the information, developing a solution, implementing that solution, and finally, on reflecting on that knowledge gained by that one problem and use it to solve more complex problems in the future. Other goals include developing abilities to implement various math principles in solving problems, interpreting and constructing tables, graphs, charts, and diagrams, and communicating these math-related principles. The secondary goals which are not adhered to directly in the tutor but might result from the experience and interaction include an increased positive attitude about math and computers in general, increased understanding of math concepts and computer skills, and a greatly improved vision of the possibilities computers have in our educational system in the future.

ADDITIONAL EXPERIENCE

Although much of my eight week experience surrounded the Intelligent Tutoring Systems, I was also introduced to other aspects related to this field including computer based instruction, software design and development, computer graphics, and Virtual Reality Systems. In computer based instruction I was able to see

previous and present computer programs involving instruction by human computer interfacing which included many educational projects. I was able to jump into the field of software design and development and see the programmers use Microsoft Windows 3.1 and the Asymetrix program Toolbook to transform the tutor from a visionary stage into a practical application. While observing the programmers I was also able to begin a computer graphics project which designed various graphics used to enhance the instructional environment. Finally, I was able to observe and participate on a Virtual Reality System which uses your vision and hand movements to transfer your body into another domain.

CONCLUSION

In conclusion, I believe the Air Force's Fundamental Skills Training Project is an excellent installation to our educational system and one which will effect our lives today and for many years in the future. It is also my opinion that the Human Resources Training and Intelligence Branch has an excellent opportunity, one which I know they will fulfill, to implement Intelligent Tutoring Systems in our schools now, so that our society can reap the benefits these systems will surely bring in the future.

My eight weeks at Armstrong Laboratory were filled with new experiences, new ideas and thoughts, and new conclusions about computer systems. I was able to observe and participate in a wide variety of applications related to or a part of the FST project in

an open environment which allowed me to seek out, find, and answer the questions I asked and challenges I faced. From this I believe I have gained a better knowledge and understanding with computer systems and the various aspects that surround them which has greatly effected my outlook and experience in this field, and has made me especially appreciative that I have had this opportunity.

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STUDENT MODEL

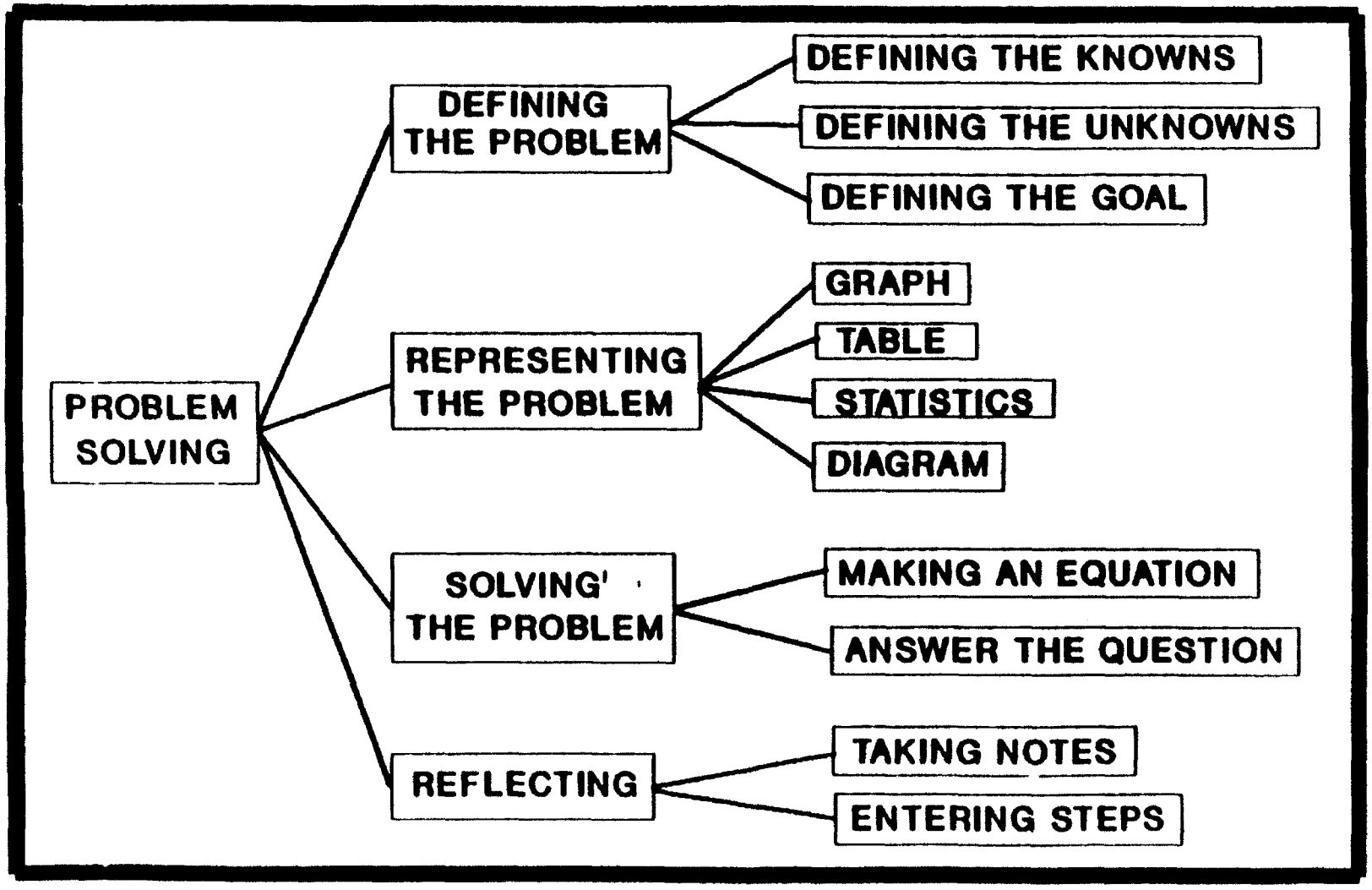

Figure 1: Guideline of student model.

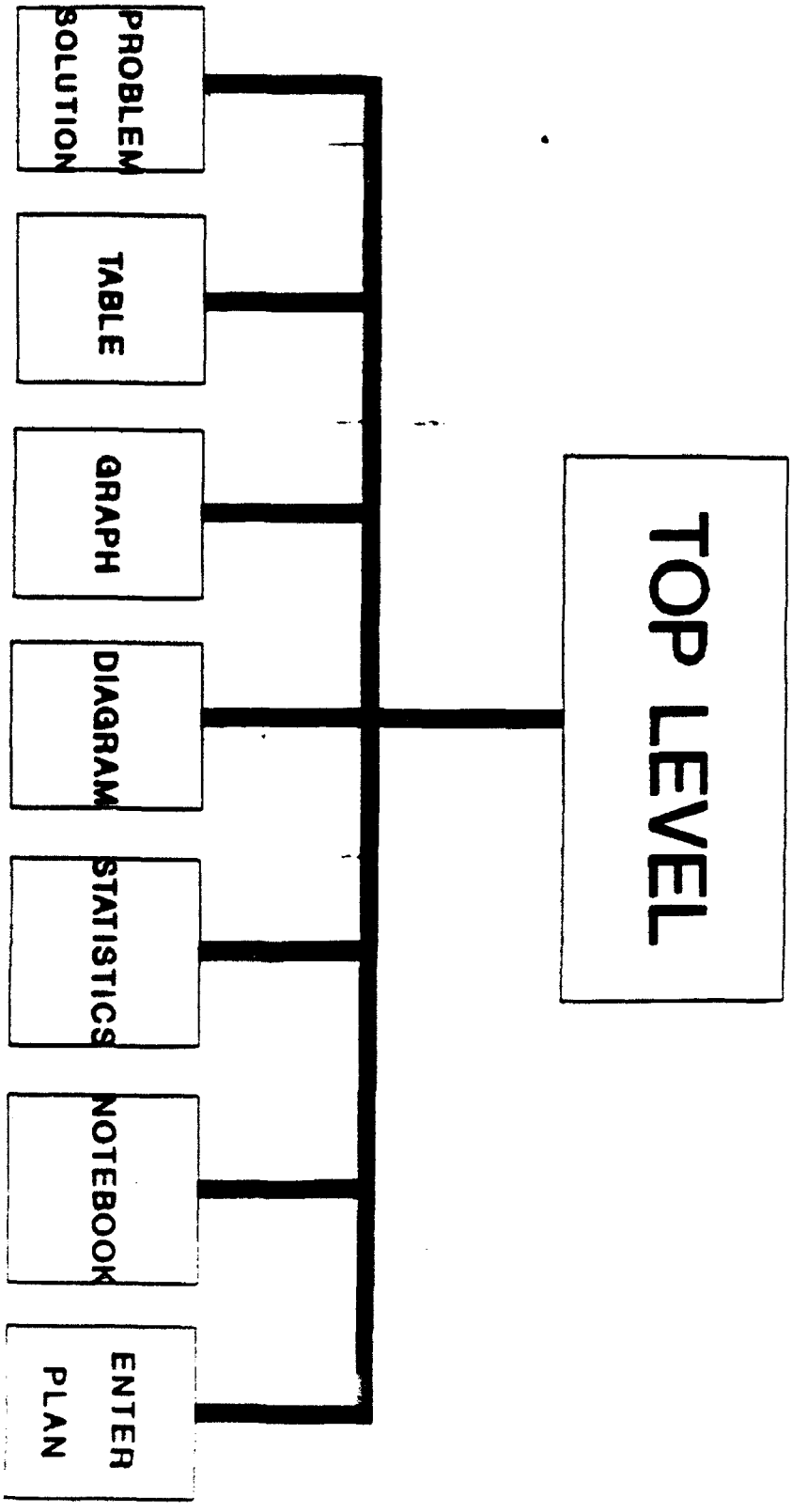

Figure 2: Overview of sections.

TUTOR INTERFACE

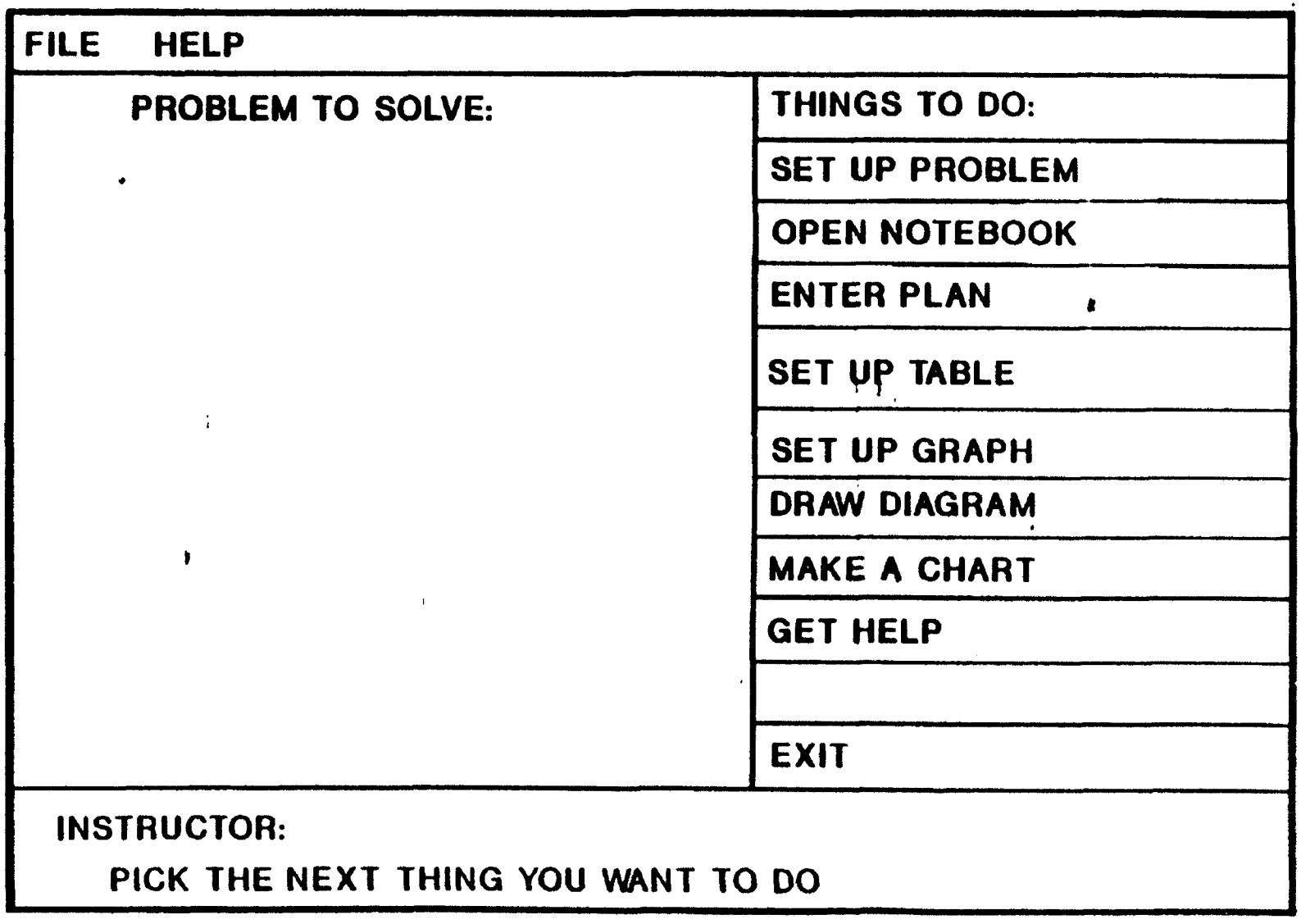

Figure 3: Menu Screen.

ENTER PLAN ITEM (SUB MENU)

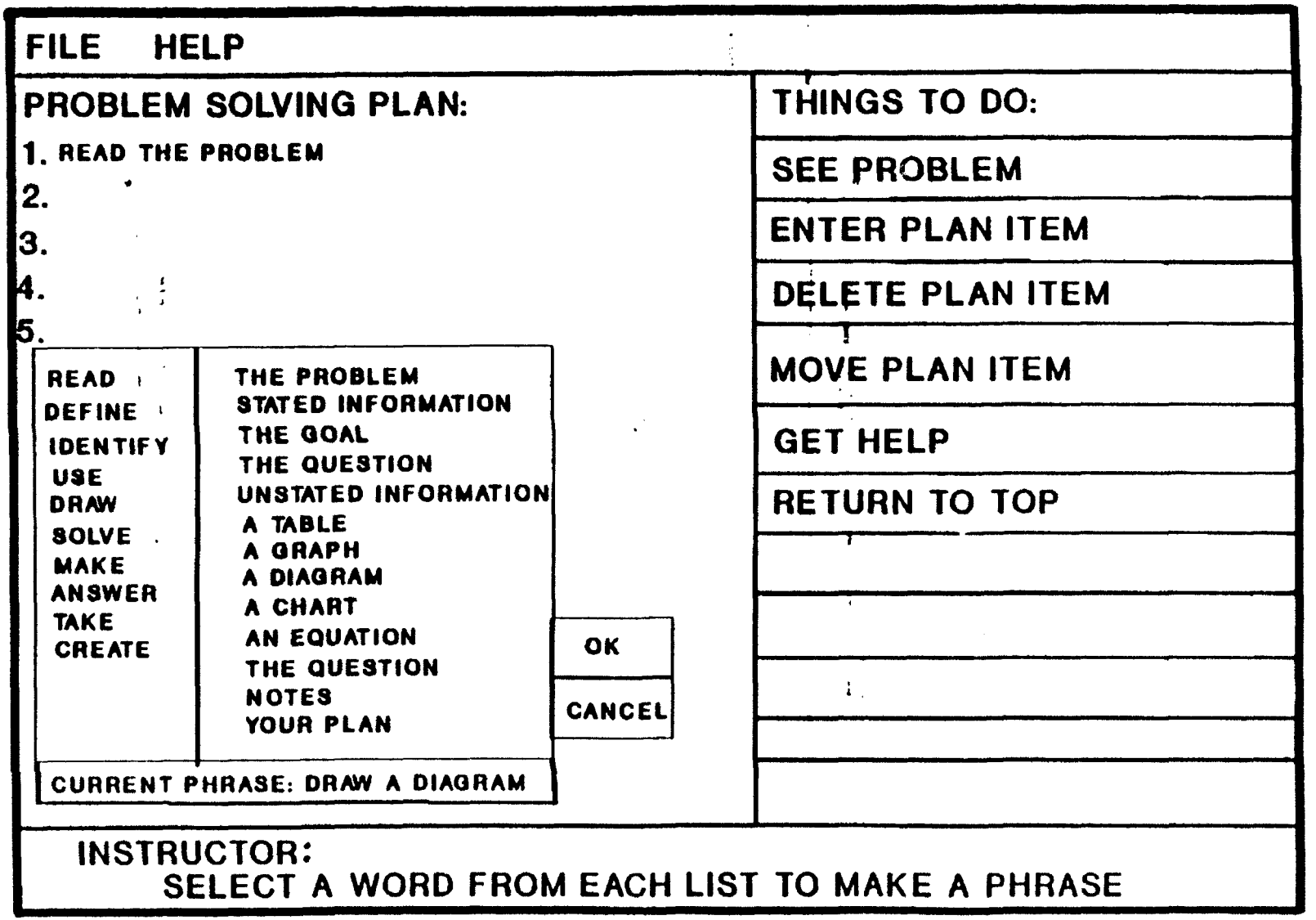

Figure 4: Screen of Problem Solving Objectives.

TEMPERATURE REGULATION IN THE HUMAN HEAD

Marsha Gayle Henke

Student, Alamo Heights High School

Final Report For:

High School Apprenticeship Program

Armstrong Laboratory

Sponsored By:

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Brooks Air Force Base, San Antonio, Tx.

August 1992

Thermoregulation in the Human Head

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Abstract

A fortran model was developed to simulate thermoregulation in the brain. By entering data on cerebral blood flow, the diminsions of the brain, core temperature, temperatures of the carotid artery and jugular vein, sweat rate, metabolic rate of the brain, and thermodynamic constants, temperatures at certain brain sites were calculated. The outer superficial tissue layer was cooler than the inner white and grey matter layers. In addition, we modeled the effectiveness of counter-current heat exchange in the neck. The heat exchange between the carotid artery and jugular vein proved to be physiologically insignificant.

TEMPERATURE REGULATION IN THE HUMAN HEAD

Marsha Gayle Henke

INTRODUCTION AND DISCUSSION OF PROBLEM

As body size increases in mammals, thermoregulation becomes more difficult. Some large mammals have a selective cooling mechanism that protects the brain, a thermally sensitive organ, from high, tissue damaging temperatures reached in other core sites. Some physiologists argue that humans have a similar protective mechanism (4, 5). Dogs, cats, and sheep have a rete mirabile, a network of arteries one to three micrometers in diameter originating from the carotid artery. The rete is surrounded by a pool of venous blood in the cavernous sinus in dogs and sheep or in the pterygoid plexus in cats (7). The venous blood comes from the nasal cavity where it is cooled by evaporation in the nasal mucosa. The cool blood then travels to the rete. Here, the arterial blood is cooled through arterial-venous heat exchange with the cool venous blood from the respiratory tract and then proceeds to the circle of Willis where it is transported through the brain (2, 9). Furthermore, evaporative cooling increases during mouth panting when the animal becomes more hyperthermic (8). However, humans rely on sweating as a principle form of heat loss (9).

Though humans lack a carotid rete, alternative brain cooling mechanisms have been proposed. Cabanac, et al claim that the human head is cooled as blood flows inwardly in the ophthalmic and emissary veins during hyperthermia (4, 5). Falk relies on this theory when she proposes that this cooling system allowed humans to develop larger brains (6). By measuring the direction of blood flow using the Doppler effect, blood in the

ophthaimic veins was shown to flow from cranium to face during hypothermia and from face to cranium during hyperthermia. Blood in the emissary veins flowed rapidly from face to cranium during hyperthermia and slowed considerably or stopped during hypothermia. His experiments did not show a reversal of blood flow in the emissary veins, yet he states that this occurs without the experimental evidence. Cabanac believes that the blood is cooled by evaporation on the face during hyperthermia and then travels to the cavernous sinus, lowering cerebral arterial temperature below trunk temperature (4, 5). However, there is more room for speculation in this theory. The emissary veins are small; many are microscopic. It is difficult to believe that these tiny veins can have a significant enough blood flow to cool the brain. Furthermore, if the ambient temperature were high enough, the cooling process could be reversed, and blood flowing from the face could warm, rather than cool, the brain. Cabanac also relies on tympanic temperature measurment as a representation of brain temperature. Some physiologists argue that tympanic temperature does not accurately measure brain temperature because it is influenced by skin and ear canal temperatures.

Cabanac's theories lack quantitative analysis, so we devised a model to quantitatively examine the heat exchange process in the human head.

METHODOLOGY

Two Fortran models were used to represent heat exchange mechanisms in the human head. The first, "HEMISPHERE", treated the brain as a hemisphere divided into four layers: (1) white matter; (2) grey matter; (3) skull; and (4) superficial tissue (fat and skin). The hemispheric model was then divided into two symmetrical halves, and two nodes were established in each layer of the resulting quarter sphere. Because each half

of the hemisphere was symmetrical, we only worked with one half, and eight nodes were used over all, four near the dividing axis between the two halves and four at the forty-five degree mark from the base of the brain to the axis.

Inputs to the program included the fraction of cerebral blood flow, the outer radius dimension, and the thermal conductivity of each layer. Additional inputs were the convergence criterion, the relaxation parameter, the cerebral mass blood flow rate, the core temperature, the inlet arterial temperature, the surface blood cooling coefficient, the ambient temperature, and the sweat rate for the head as a whole.

From this data, the temperature at each node was determined. First, the metabolic heat generation of each layer was calculated by assuming that heat generation is directly proportional to blood flow rate. The program then utilized finite difference heat exchange equations to calculate the effective thermal conductivity between adjacent layers. Two matrices, one eight by eight (MATRIX A) and one eight by one (MATRIX C) were then established through further heat exchange calculations. MATRIX A multiplied by an unknown eight by one MATRIX X equaled MATRIX C, and by using the Gauss-Seidel method, MATRIX X, which consisted of the outlet temperatures of each node, was calculated to produce mathematically modeled brain temperatures at certain sites.

In addition to the "HEMISPHERE" model, we devised another Fortran program, "HOTPIPE", that modeled counter-current heat exchange between the jugular vein and the carotid artery. Input values included the carotid and jugular volumetric flow rates, the mass density and viscosity of blood, the specific heat and thermal conductivity of blood, the length that the jugular vein and the carotid artery were paired, the diameters of the two vessels, their inlet temperatures, and the distance away from each other when paired. From these values, the model determined the temperature change in the arterial blood, the heat exchange between the two vessels, and the effectiveness of the heat exchange mechanism.

RESULTS

Using the values for the variables listed in the appendix, the "HEMISPHERE" model showed the highest temperatures in the two inner layers, the white and grey matter, and the lowest temperatures in the outer superficial tissue layer. The gradient between the highest and lowest temperatures was 1.7°C In the white matter, the temperature at the forty-five degree mark was 39.2°C, 0.2°C lower than the temperature of the node by the axis in the same layer. Both temperatures in the grey matter were also 39.4°C. In the skull, the temperature dropped by 0.7°C from the two inner layers, as each node was calculated to be 38.7°C. Finally, the outer superficial tissue layer was significantly cooler with both nodes at 37.7°C.

In the "HOTPIPE" program, the inlet venous temperatures (34°C or 36°C) and the length of the carotid and jugular pairing were varied to see how they affected the temperature change (ΔT), heat exchange, and effectiveness of the counter-current mechanism in the neck at different venous and arterial flow rates (2.0, 4.0, or 6.0 ml/s). ΔT remained nearly constant and physiologically insignificant for each case, with the greatest change being 0.03°C when the venous inlet temperature is 34°C and the length is 20 cm, which is longer than the pairing in the human neck. Changing the length of the pairing to a more reasonable 13 cm lowered ΔT. Raising the venous inlet temperature to 36°C also lowered ΔT as did increasing the arterial blood flow rate.

The heat exchange between the arterial and venous blood also proved to be insignificant. The greatest heat exchange per °C was 0.28 watts when the length was 20 cm, the arterial flow rate was 6 ml/s, and the venous flow rate was 4 or 6 ml/s. Arterial and venous flow rates seemed to have a small effect on heat exchange, as slower flow rates showed somewhat less of a heat exchange, even though there was a greater

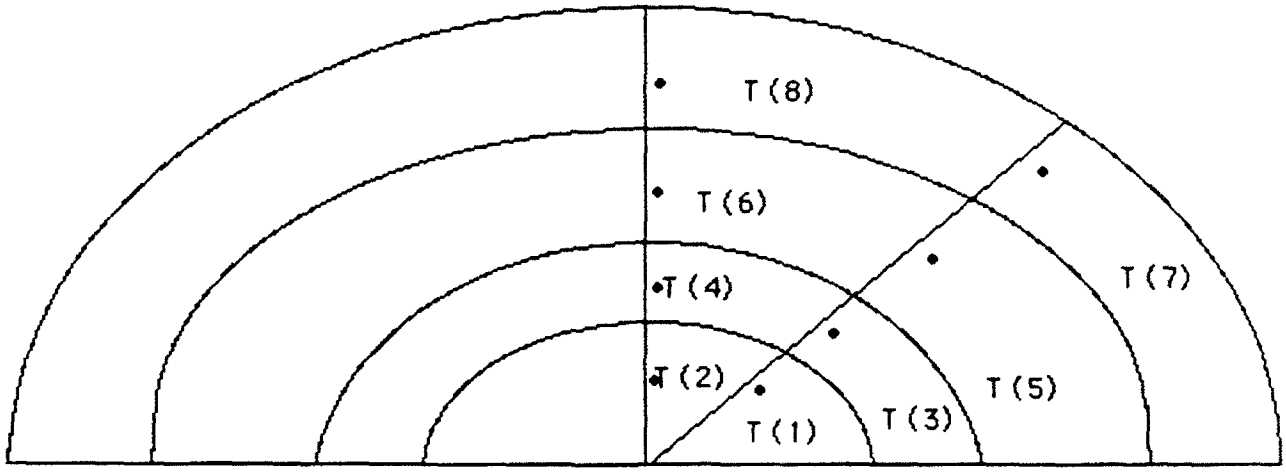
temperature change when the flow rates were slower. The length of pairing of the carotid and jugular had a greater effect of 0.11 watts per °C when the length was changed to 13 cm.

The effectiveness of the counter-current heat exchange in the neck was minimal. The greatest effect occurred when the length was 20 cm, longer than in humans, and when the difference between the arterial and venous flow rates was the greatest. See the appendix for complete results.

CONCLUSIONS

The results from the two models provide a groundwork for future investigation into the cooling mechanisms of the brain. By quantatively analyzing brain temperature in humans, the need for specific brain cooling mechanisms can be analyzed. Later experiments can also be developed to confirm the models' findings.

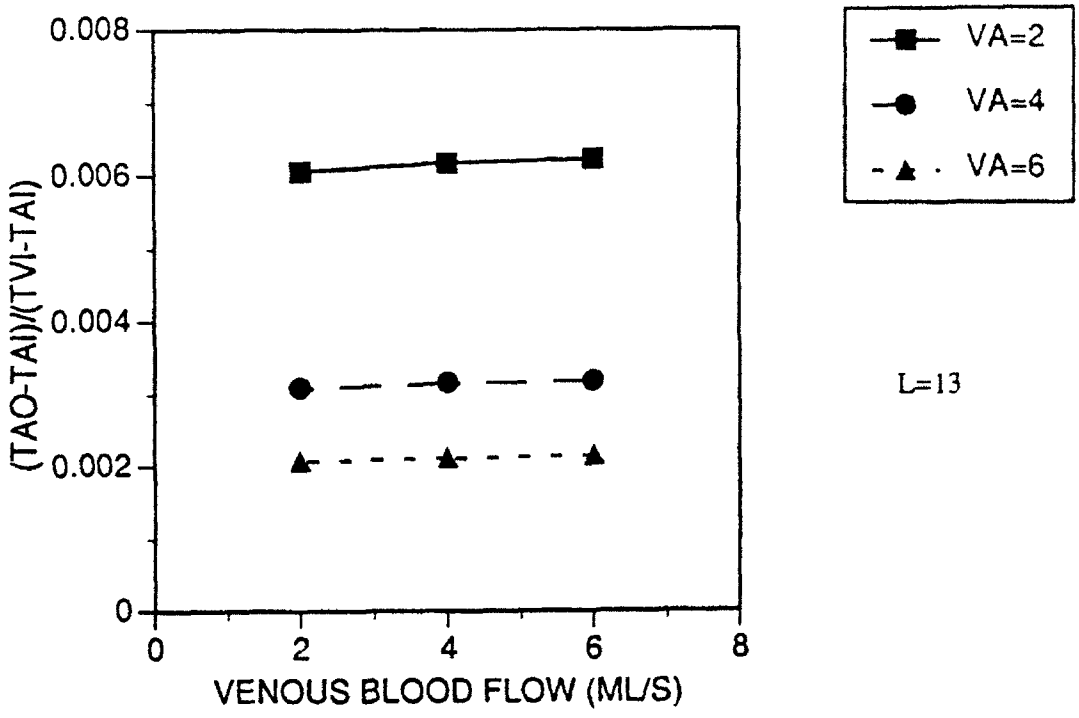
APPENDIX



• = NODE

HEMISPHERE RESULTS
T (1) = 39.2°C
T (2) = 39.4°C
T (3) = 39.4°C
T (4) = 39.4°C
T (5) = 38.7°C
T (6) = 38.7°C

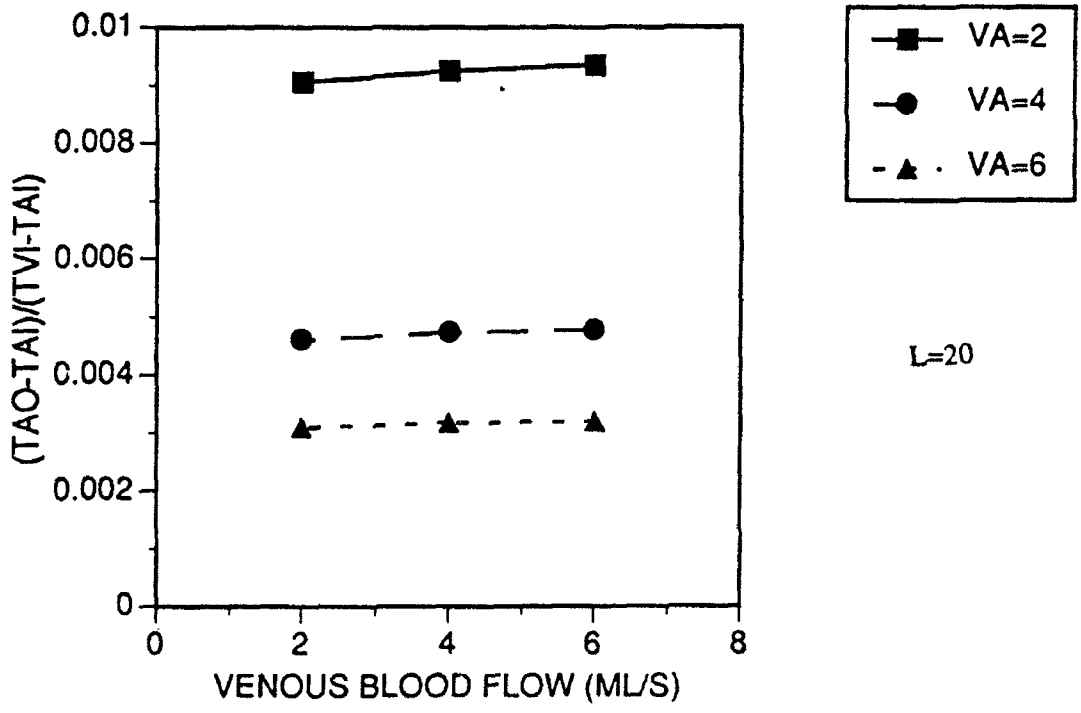
RESULTS FROM "HOTPIPE"

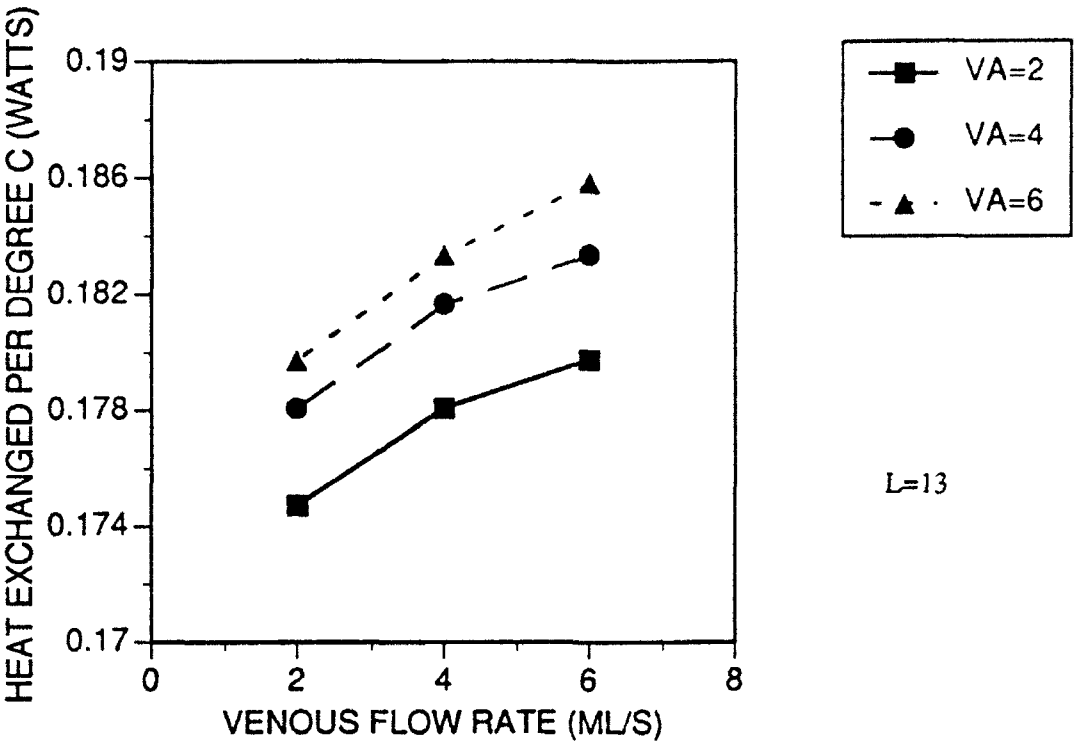


TAI = INLET ARTERIAL TEMPERATURE

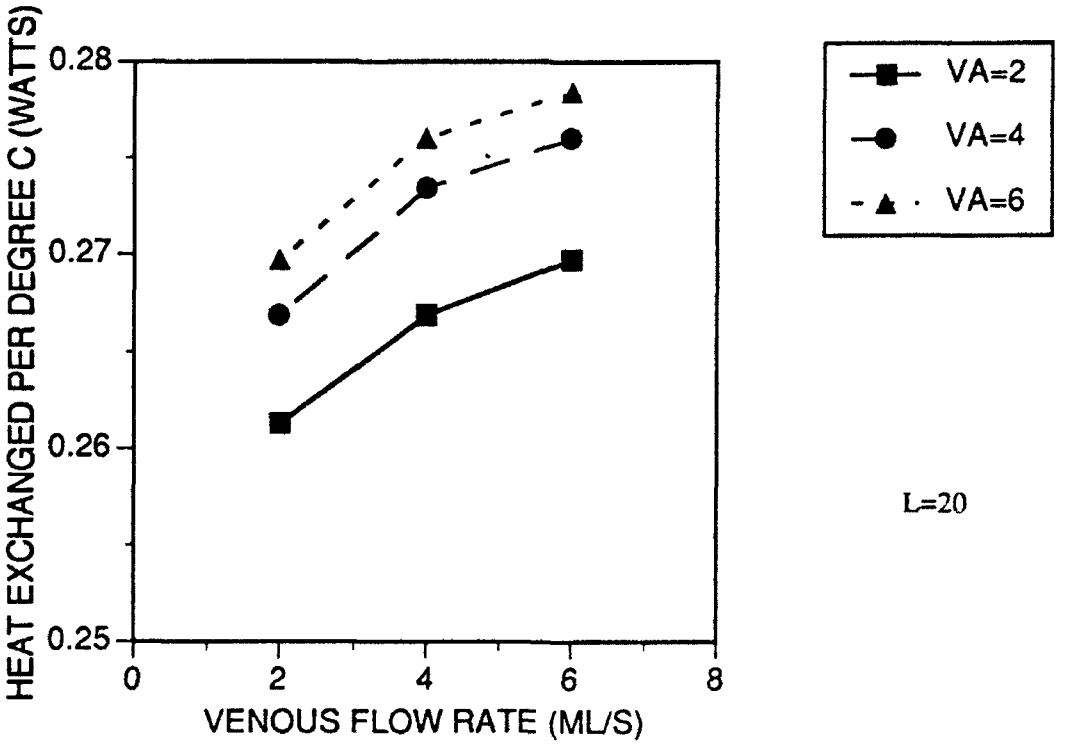
TAO = OUTLET ARTERIAL TEMPERATURE

TVI = INLET VENOUS TEMPERATURE

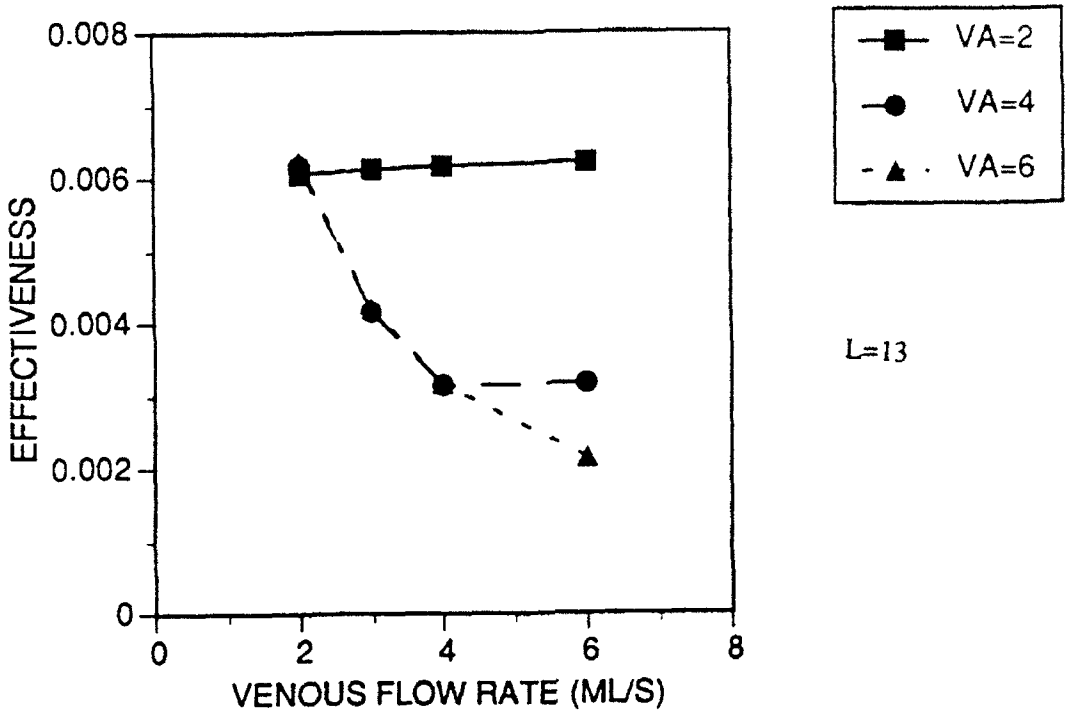



HEAT EXCHANGED PER DEGREE C (WATTS)
0.19
0.186
0.182
0.178
0.174
0.17
0
2
4
6
8
VENOUS FLOW RATE (ML/S)
VA=2
VA=4
VA=6

L=13


HEAT EXCHANGED PER DEGREE C (WATTS)
0.28
0.27
0.26
0.25
0
2
4
6
8
VENOUS FLOW RATE (ML/S)
VA=2
VA=4
VA=6

L=20


0.008
0.006
0.004
0.002
0
EFFECTIVENESS
0
2
4
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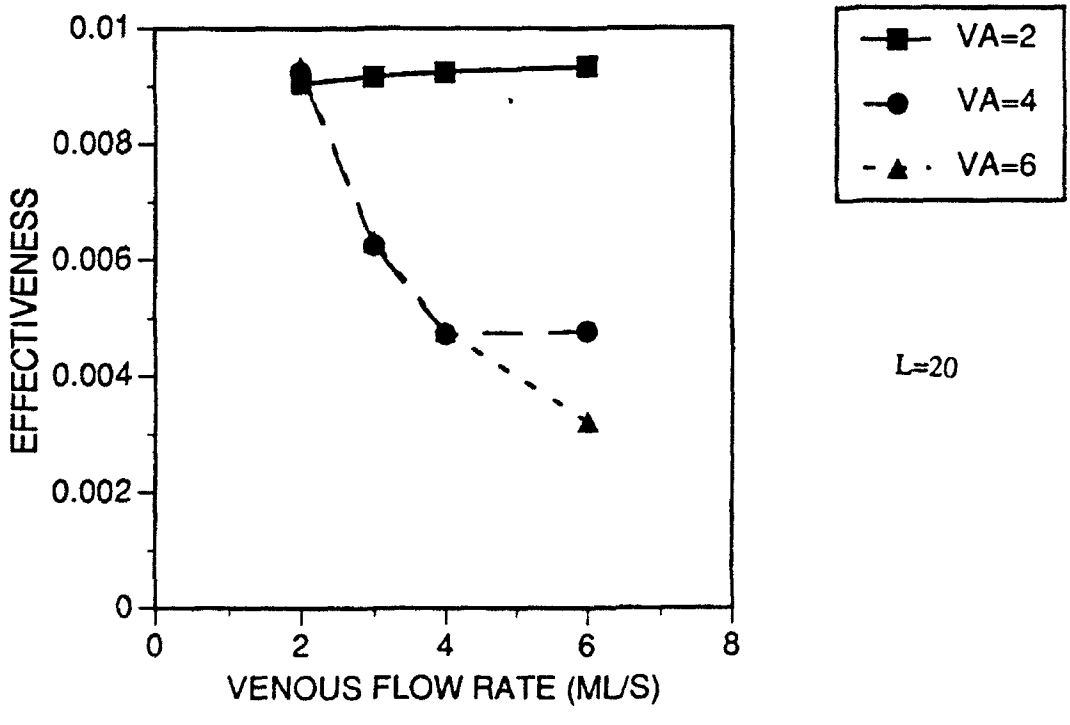
VENOUS FLOW RATE (ML/S)
VA=2
VA=4
VA=6

L=13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EFFECTIVENESS
0
2
4
6
8
VENOUS FLOW RATE (ML/S)
VA=2
VA=4
VA=6

L=20

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THE OPTIMIZATION OF HCFC-123 REDUCTIVE METABOLISM

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Armstrong Laboratory

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August 1992

THE OPTIMIZATION OF HCFC-123 REDUCTIVE METABOLISM

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High School Apprentice

Abstract

The optimal conditions of substrate concentration, time, and protein concentration for the microsomal reductive metabolism of HCFC-123 was studied. Incubations varying these conditions were conducted using rat liver microsomes, and metabolite formation was determined using gas chromatography. Experimental results indicated that a linear rate of metabolite formation could be established under 36% substrate concentration, an incubation time of 3 minutes, and a protein concentration of 4 mg/ml. These conditions could then be applied in a study comparing the effects of various chemicals on the microsomes' metabolism of HCFC-123.

Introduction

Halon 1211 is a compound currently found in fire extinguishers utilized by the United States Air Force. Unfortunately, Halon 1211 is also a chlorofluorocarbon which when released results in depletion of the atmosphere's ozone. Now, due to such acts as the Montreal Protocol of 1987 and the Clean Air Act of 1990, a replacement for Halon 1211 must be found. One of the candidates is HCFC-123. This chemical is structurally similar to the compound halothane which is already known to be toxic to the human liver. Consequently, it is necessary to conduct a thorough investigation into the metabolism of HCFC-123 so as to assess its toxicity and viability for practical use. Part of this investigation involves optimizing the conditions of HCFC-123's reductive metabolism so that a linear rate of metabolite formation can be established for use in a comparative study. The conditions optimized in this study were substrate concentration, time of incubation, and protein concentration.

Materials and Methods

Chemicals

HCFC-123 (2,2-dichloro-1,1,1-trifluoroethane) was purchased from Allied Signal, Inc. All other reagents were obtained from Aldrich Chemical Co., unless specified otherwise.

Animals

Male Sprague-Dawley rats from Charles River Breeding Lab (Kingston, NY). These rats were quality control tested and group housed in cages where both food and water were available. The surrounding temperature of the animal room ranged from 21-25°C, and a light-dark cycle ran at 12-hr intervals.

Preparation of Hepatic Microsomes

Livers from the rats were perfused through the inferior vena cava with a cold buffer mixture of 0.154 M KCl and 0.05 M Tris HCl (pH 7.4). Then the livers were weighed, minced, and homogenized in a volume of the cold Tris buffer (volume in ml=four times the liver's weight in grams). After a series of centrifugations, a microsomal pellet was obtained which was then rinsed and resuspended in the Tris buffer. The microsomes were then frozen in liquid nitrogen and placed in a freezer at -80°C for storage.

Pierce BCA Protein Assay (from assay kit)

A set of protein standards of known concentration were prepared by diluting the stock 2 mg/ml bovine serum albumin in 0.1 M Tris buffer. Then 0.1 ml of each standard was pipetted into a labelled test tube. The same was done with the unknown protein samples. A blank was prepared with 0.1 ml of the Tris buffer. Then 2.0 mls of the working reagent (50 parts BCA base

reagent and one part 4% copper sulfate solution) was added to each test tube. All the test tubes were then vortexed and incubated at 37°C for 30 min. The blank and the standards were then transferred to quartz cuvettes and run on a Gilford spectrophotometer at an absorbance wavelength of 562 nm. The Gilford then plotted out a standard curve which, if of a high enough correllation coefficient (close to 1.00) was used to determine the protein concentration of the unknown samples.

Optimization of HCFC-123 Reductive Metabolism

Substrate Dependence Study

Six 25 ml Erlenmeyer flasks were covered with Teflon-lined silicon septa, capped, and then evacuated under vacuum for 2 min. each. Each flask was then purged with nitrogen gas at a rate of 1.0 L/min. The gas entered the flask one 20 gauge needle and was vented out through another. After allowing the microsomes to thaw, 3.9 mls of the microsomes was added to 10.1 mls of 0.1 Tris buffer to establish a protein concentration of approximately 4 mg/ml. The Tris had previously been brought to a pH of 7.6 with the needed amount of sodium hydoxide. The microsome suspension was placed in an Erlenmeyer flask with a side arm and was then put on ice and bubbled with nitrogen gas for 10 min. During the bubbling the flask was vigorously swirled at 1 min. interevals to ensure proper equilibration.

Then, using a gas-tight syringe, 2.0 mls of the microsome suspension was added to each flask which was then placed in a water bath at 37°C. The exact protein concentration of the suspension was later determined by the BCA assay. The flasks were then dosed in order to establish headspace concentrations of 6%, 15%, 24%, 36%, 48%, and 75%. The flasks were then preincubated at 37°C in a Dubnof Metabolic Shaking Incubator (GCA/Precision Scientific, Chicago, IL) for 15 min at 160 oscillations/min. After the preincubation period, the reaction was initiated in each flask by an injection of 25 ul of B-NADPH solution. After 20 minutes the reactions were then stopped by placing the flasks on an 85°C hot plate. The flasks were then placed in a 37°C oven untils they could be analyzed for volatile matabolites by gas chromatography.

Time Course Study

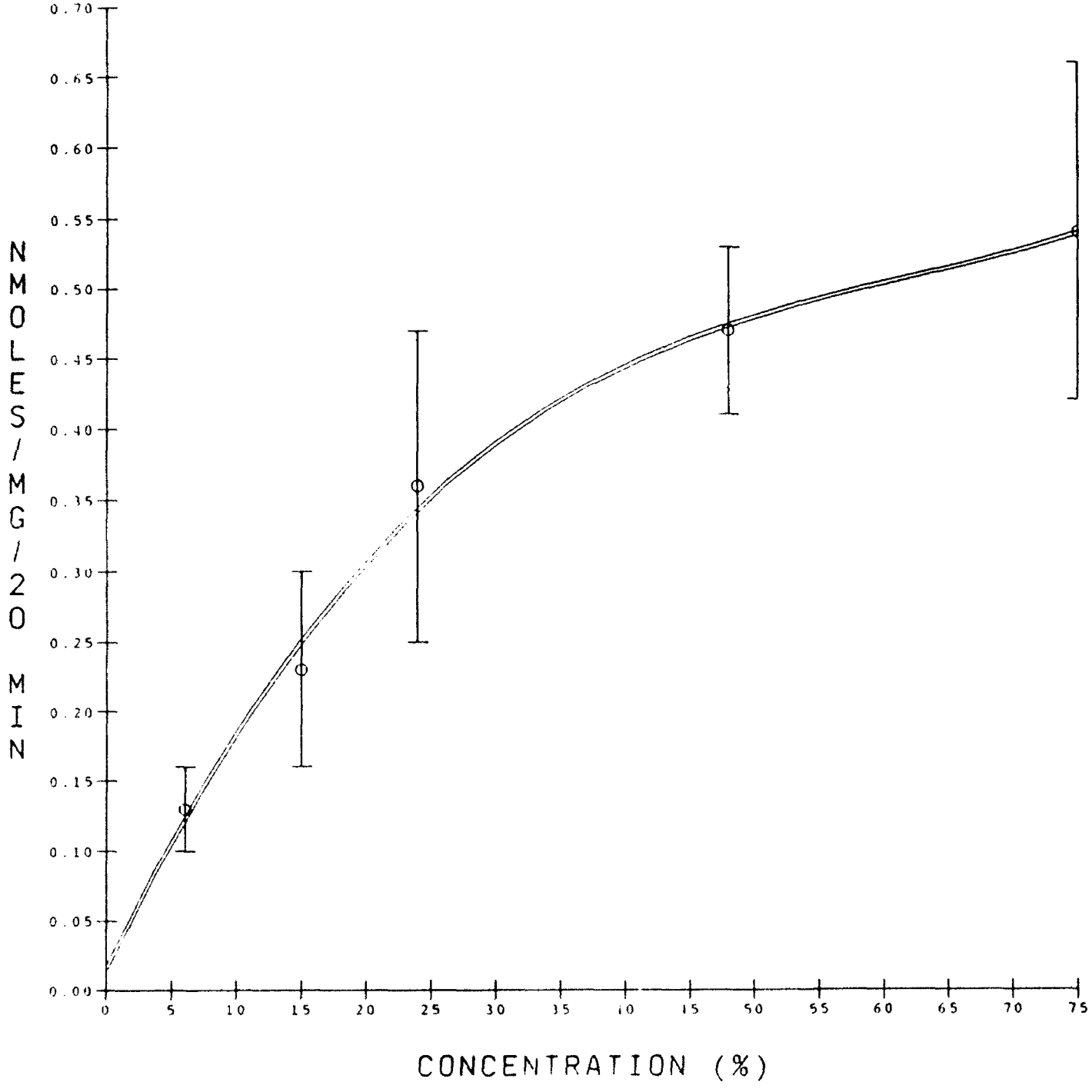
This procedure to study the relationship of the reductive metabolism to incubation time was basically the same as above except that each flask had a substrate concentration of 36%. Here again the microsomal protein concentration was 4 mg/ml. The reactions were then initiated and stopped at intervals that allowed the first flask to react for 1 min., the second for 3 min., the third for 7 min., the fourth for 20 min., the fifth for 40 min., and the sixth for 60 min.

Protein Dependence Study

Here again each reaction in the flasks had a substrate concentration of 36% (optimal concentration), however only four flasks were used. Each flask had its own microsomal suspension that was bubbled with nitrogen for 10 min. These suspensions ranged in protein concentration from 1-4 mg/ml. The first flask's suspension was the 3.9 mls of microsomes and 10.1 mls of the Tris buffer. The second flask's suspension was made of 3.0 mls of the first flask suspension plus 0.99 mls of Tris. The third flask's consisted of 2.0 mls of the first flask suspension and 2.0 mls of Tris, and the last flask's suspension contained 1.0 mls of the first flask suspension and 3 mls of Tris. In this study the exact protein concentrations of all four microsomal suspensions was then determined by the BCA assay.

Results

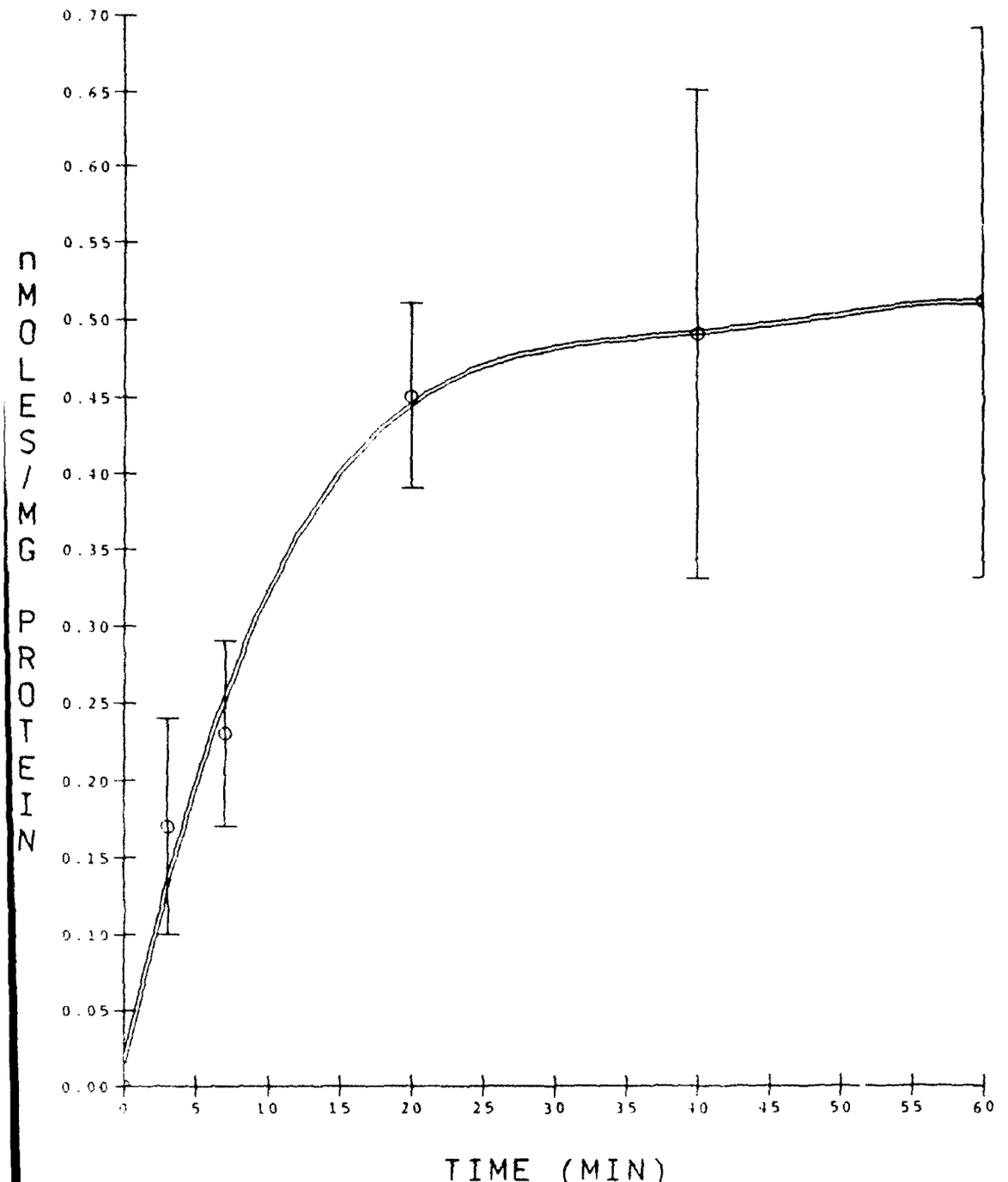
As shown in figure 20:1, there is a nonlinear correlation between the percentage of substrated in the headspace of each flask and the rate of formation of the metabolite HCFC-133a. The production of HCFC-133a was continually on the increase from 6% to 75% and began to show substrate saturation after 36%. Because the metabolite formation at 36% was close enough to the maximum rate, this was the substrate concentration chosen for the ensuing comparative study.


0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
NMOLES/MG/20 MIN
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
CONCENTRATION (%)

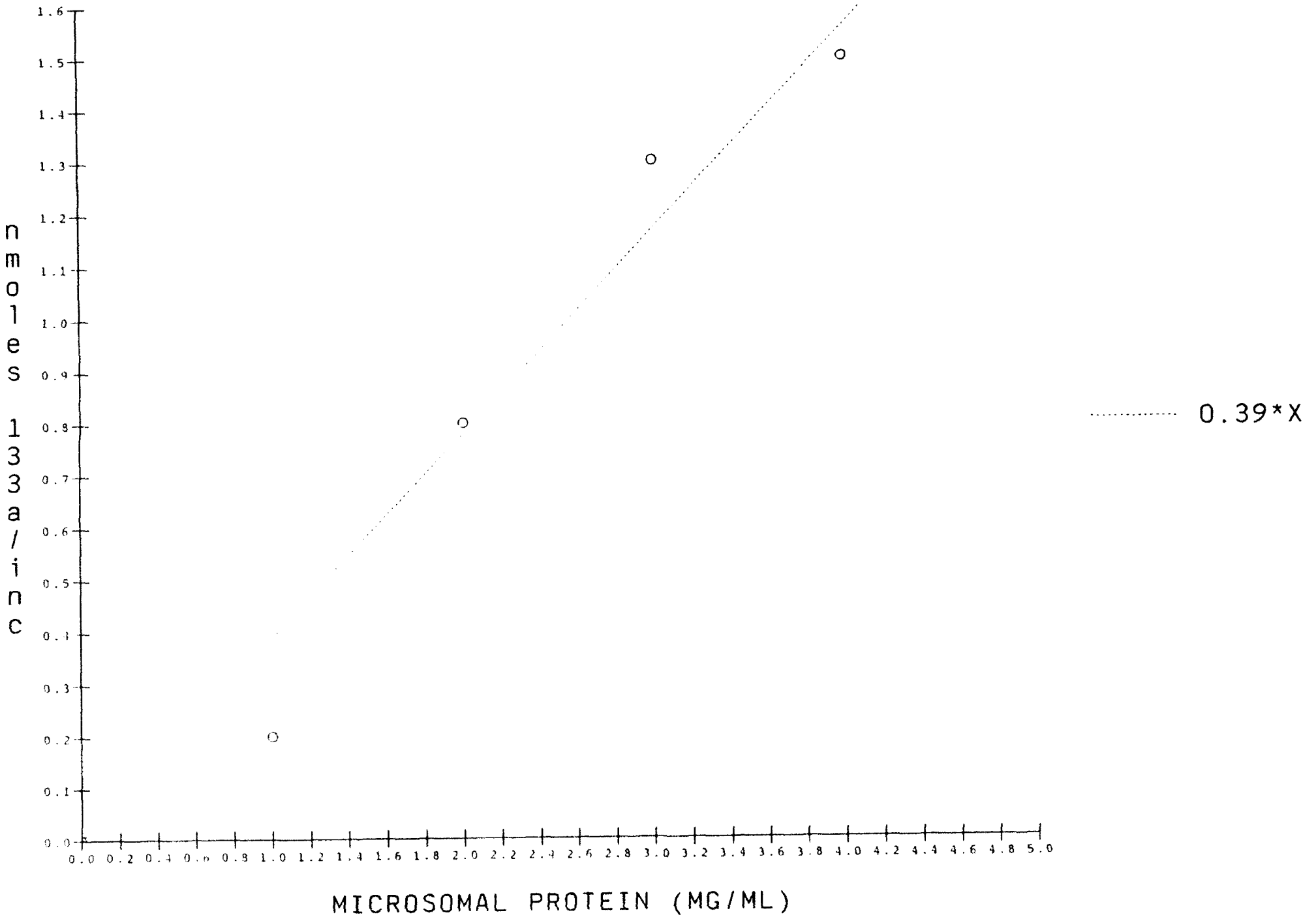
20-8

OPTIME

10-AUG-92 18:30 Page 1



20-9


nmoles 133a/inc
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0 4.2 4.4 4.6 4.8 5.0
MICROSOMAL PROTEIN (MG/ML)
0.39*X
20-10

In the time course study it was found that after about 20 min. the amount of HCFC-133a was nearly at its maximum (see figure 20:2). However, from 0-5 min., the graph is fairly linear, and for this reason an incubation time of 3 min. was used in the comparative study.

As shown by the graph in figure 20:3, the amount of HCFC-133a per incubation increased with the protein concentration over a range of 1 to 4 mg of protein. Since the plot was linear, it allowed a protein concentration of 4 mg/ml to be used in the comparative study.

Conclusion

Because it is so structurally similar to halothane, it is reasonable to assume that HCFC-123 will follow the same pathway of reductive metabolism. Under conditions of near 0% oxygen, rat liver microsomes metabolize HCFC-123 to a carbon-centered radical (Casarett & Doull, 1991) later forming HCFC-133a which is carcinogenic. The goal of this particular study was to determine the optimal metabolic conditions necessary to establish a linear rate of metabolite formation. Collectively, these were a substrate concentration of 36%, an incubation period of 3 min., and a protein concentration of 4 mg/ml. Using these conditions, it was then possible to carry out a comparative study analyzing the influence on metabolite formation rate with microsomes induced with such compounds as pyridine and phenobarbital.

References

C.S. Godin, PhD., Project Scientist, Mantech Environmental Technologies, Inc., RDL mentor/adviser.

Casarett & Doull's Toxicology, Ch. 4, Biotransformation of Toxicants, I. Glenn Sipes & A. Jay Gandolphi, pp. 90-95.

A STUDY OF THE SPRING AND DAMPING CONSTANTS IN THE WIRE ROPES OF PARACHUTES

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Escape and Protection Branch

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FInal Report for:
Summer Research Program
Armstrong Laboratory

Sponsored by:
AFOSR
Research Development Laboratories
Culver City, California

August 1992

A STUDY OF THE SPRING AND DAMPING CONSTANTS IN THE WIRE ROPES OF PARACHUTES

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ABSTRACT

The spring and damping constants of the wire ropes of a parachute were studied. With the use of a drop tower, the stresses during a parachute drop were simulated, using a 66lb. lead weight as the test subject. Accelerometers were placed on the left and right sides of a boomerang structure, from which the wire ropes were suspended. Another accelerometer was placed on the center of the top surface of the lead weight. The Z axis accelerations were used for this study. The average of the boomerang accelerations were entered into an equation involving spring and damping constants and were compared to the acceleration reading from the lead weight. The data was run through the model and trial and error were used to determine C (damping constant) and K (spring constant) in a graph comparison. Nine trials were used to collect the data.

A STUDY OF THE SPRING AND DAMPING CONSTANTS IN THE WIRE ROPES OF PARACHUTES

Jennifer M. Kim

INTRODUCTION

In the Escape and Protection Branch of the Armstrong Laboratory, many tests are conducted to obtain maximum performance with minimum injury. The conducting of the parachute study provided data involving accelerations, which could then be used to determine the damping and spring constants in the wire ropes used to suspend the test subject to the apparatus. Once these factors could be analyzed, a more accurate result set could be used to lessen the amount of stress experienced by the test subject.

METHODOLOGY

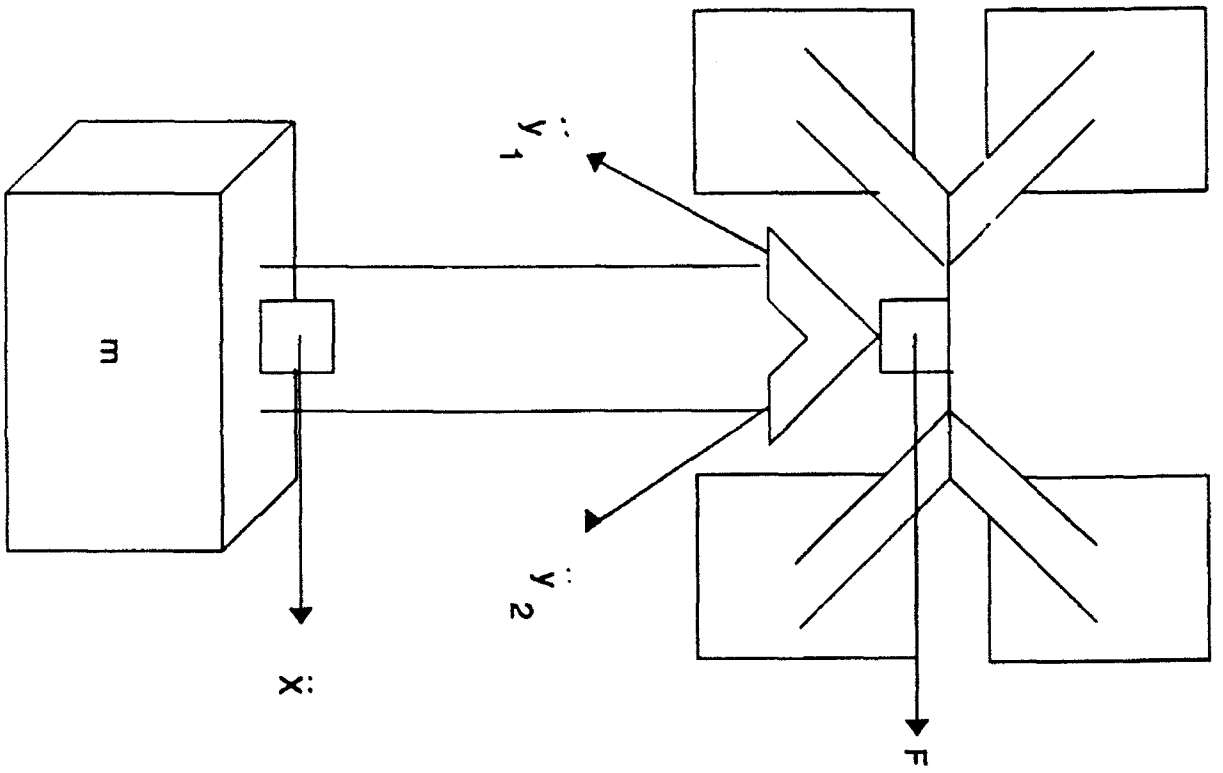
The first method attempted to find the spring and damping constants involved a comparison of forces. A load cell was placed at the vertex of the boomerang to measure the force exerted by the lead weight when dropped. This Z axis force, after being zeroed, was compared to the force derived from the accelerations in the following equations:

1) $F= C(dx/dt - dy/dt) + K(X-Y)$

2) $F= ma$

3) $Fz= C(dx/dt) + KX$

The Y variable represents the average of the boomerang accelerations after the second integral has been take. The X variable represents the second integral of the lead weight


m
y1
y2
x
F

accelerometer. With the force from the load cell to be used in comparison, values for C and K could be found by using the Matrixx program on a trial and error basis. Using System Build in the Matrixx, a model was constructed (Appendix 21-A), displaying the paths of integration and calculation to give the output. Then a command file was written for the model (Appendix 21-B). The lead weight drop tests took place on 06/16/92 and 06/17/92. A total of nine drops were done with the 66lb. lead weight. The distance from the floor to the riser release was 11'3", the height of the SDD platform was 10'1", and the drop distances varied from 3" to 6" to 9". Three different lengths of wire rope were used, being 36",42", or 48".

After the data had been collected, the results were run through DADISP and QBASIC MATCONE1 and MATCONE2 to provide the needed input and output signals to be run through the Matrixx model through the command file. Trial and error provided the values for C and K, and the results were plotted on a comparison graph. However, this first process did not provide the necessary results, due to various bugs in the program. A second approach was tried.

This approach involved a comparison of accelerations instead of forces. By using the following equations:

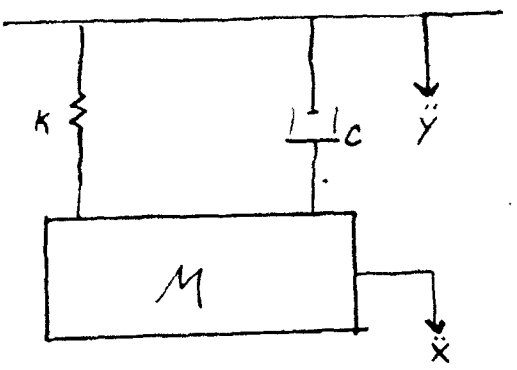
1) r+2 w r+w r=-y

2) r= -y-2 w r-w r

a basic model was constructed in the Matrixx System Build.

06/15/92

2nd effort



$$F = m \cdot a$$

$$-K(x-y) - c(\dot{x}-\dot{y}) = F$$

$$\therefore -K(x-y) - c(\dot{x}-\dot{y}) = m\ddot{x}$$

$$r = x - y \qquad x = r + y$$

$$-kr - c\dot{r} = m\ddot{r} + m\ddot{y}$$

$$m\ddot{r} + c\dot{r} + kr = -m\ddot{y}$$

$$\ddot{r} + \frac{c}{m}\dot{r} + \frac{K}{m}r = -\ddot{y}$$

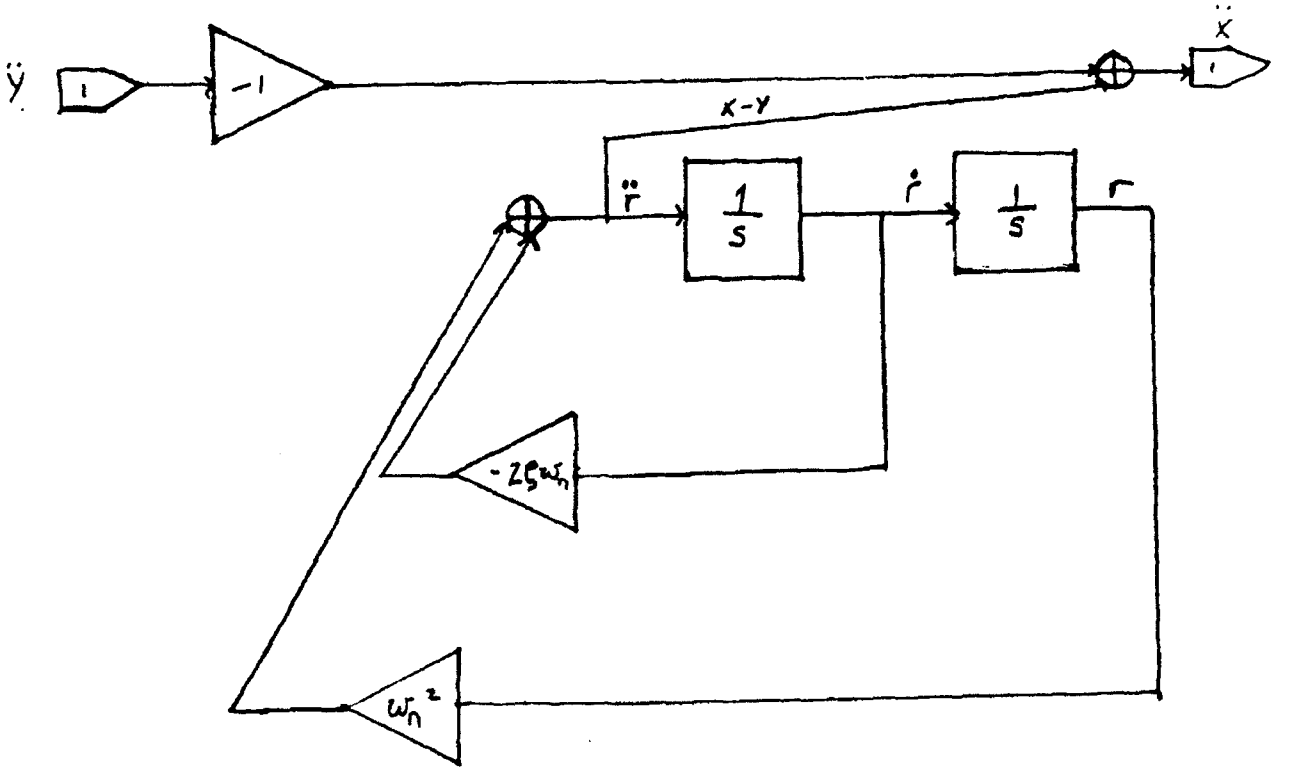
$$\omega_n = \sqrt{\frac{K}{m}}$$

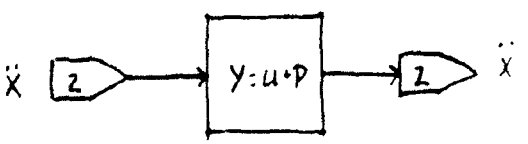
$$\zeta = \frac{c}{c_c}$$

$$\frac{c}{2m} = \zeta \frac{c_c}{2m} = \zeta\omega_n$$

$$\ddot{r} + 2\zeta\omega_n\dot{r} + \omega_n^2 r = -\ddot{y}$$

$$\ddot{r} = -\ddot{y} - 2\zeta\omega_n\dot{r} - \omega_n^2 r$$





However, this effort, too, did not provide the necessary results.

In a third attempt, the comparison was still between the accelerations, but in a simplified form. By using the following expression:

$$-MX-K(X-Y)-C(X-Y)=0$$

$$MX+CX+KX=KY+CY$$

where M is a constant, the lead weight Z axis acceleration would be compared to the average of the boomerang Z axis accelerations. Another model was built with a command file. DADISP was used to prepare column files for time, the lead weight Z axis acceleration, and an average of the two boomerang accelerations. The data was run through QBASIC MATCONE1 and MATCONE2 to provide the needed input and output signals. The results were run through the model, values were guessed for C and K, and the results plotted on a graph. The results were satisfactory.

RESULTS

The results of this project were limited to one set due to time constraints. The values of C and K were 5 and 100, respectively. The results were plotted on a T,Y plot and compared with the ideal results (Graph 1). A closer analysis was done over the X minimum of 650 and the X maximum of 700 (Graph 2).

20000
15000
10000
5000
0
−5000
−10000
−15000
−20000
−25000
−30000
Y
400
500
600
700
800
900
1000
1100
T

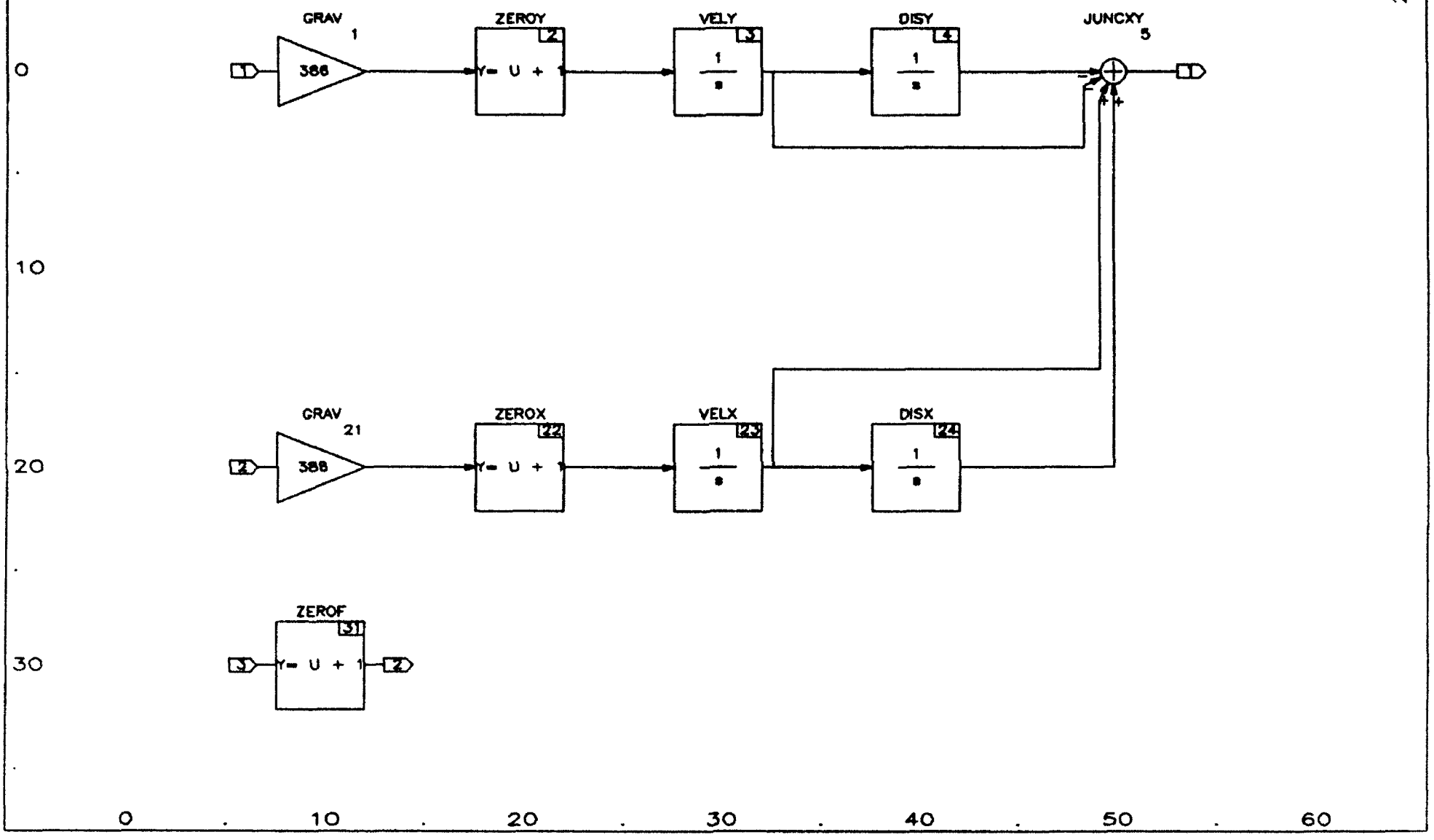
12000
9000
6000
3000
0
-3000
-6000
-9000
-12000
Y
650
655
660
665
670
675
680
685
690
695
700
T

CONCLUSION

The third model used for analysis proved to be the most accurate. However, after analyzing the data provided in the graphs, the values of C and K used that provided the closest results provided those results in an inverted wave compared to the ideal result. This may be due to bugs in the program, or may be attributed to a reversal of signs (+,-) on the variables. Also, because C and K were found by trial and error, they are not exact. However, they may be close enough to the actual values to be used.

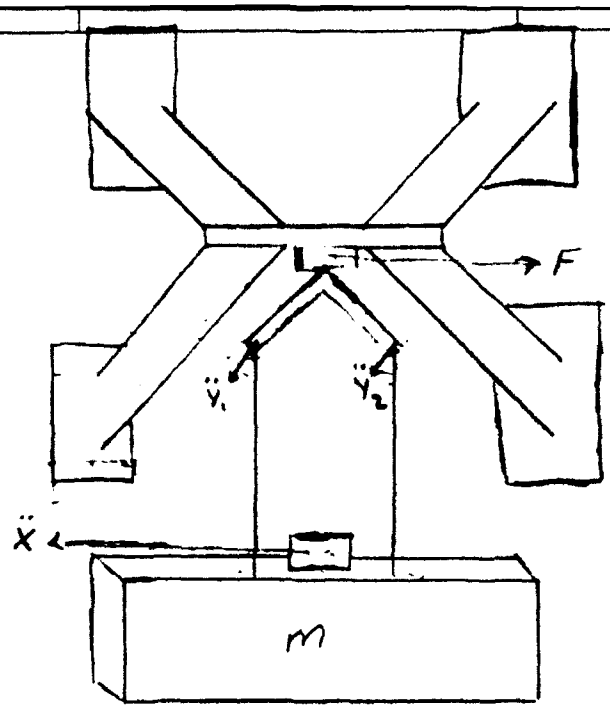
APPENDICIES

Continuous Super-Block	Ext.In	Ext.Out
ROPE	3	2



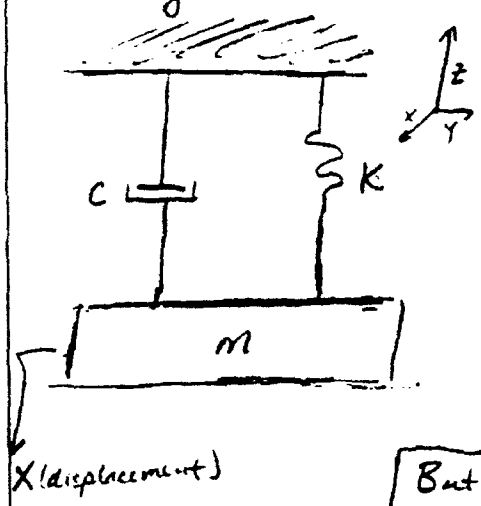
```
LOAD 'F:\KIM\ROPE.MOD'
EXEC ('F:\KIM\T.DAT')
EXEC ('F:\KIM\U.DAT')
SC=0
HC=0
FC=0
FOR I=1:10,...
SC=SC+U(I,1),...
HC=HC+U(I,2),...
FC=FC+U(I,3),...
END
FFY=(-.1)*SC
FFX=(-.1)*HC
FFF=(-.1)*FC
OFFY=[FFY]
OFFX=[FFX]
OFFF=[FFF]
INQUIRE C "C"
INQUIRE K "K"
C1=[C]
B=K/C
C2=[B]
C3=[C]
C4=[B]
BUILD,ANAL,ROPE,Y=SIM(T,U)
PLOT(T,Y)
```

A)



LW (leadweight)
64 lb. w/o harness
(altered from AD, CG, HU testing)

B) If $y = 0$



C: damping constant
K: spring constant

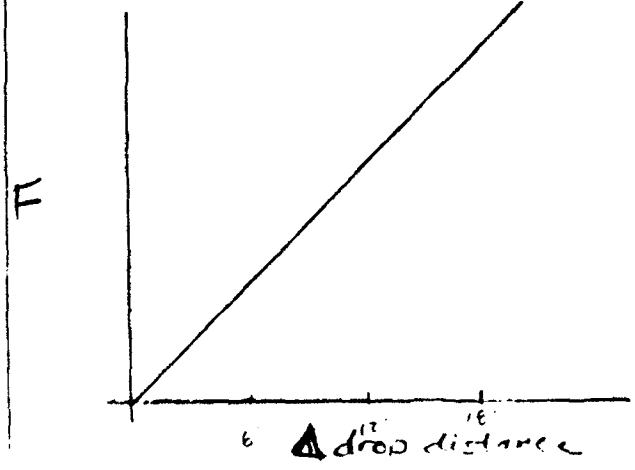
$F = m \cdot a$ } cross check

$F_z = C\frac{dX}{dt} + KX$

$\boxed{\text{But } y \neq 0}$ $\therefore$ $\ddot{y}_1$ and $\ddot{y}_2$ are averaged

$\ddot{y} = \frac{1}{2}(\ddot{y}_1 + \ddot{y}_2)$

$$F = C\left(\frac{dx}{dt} - \frac{dy}{dt}\right) + K(X - Y)$$

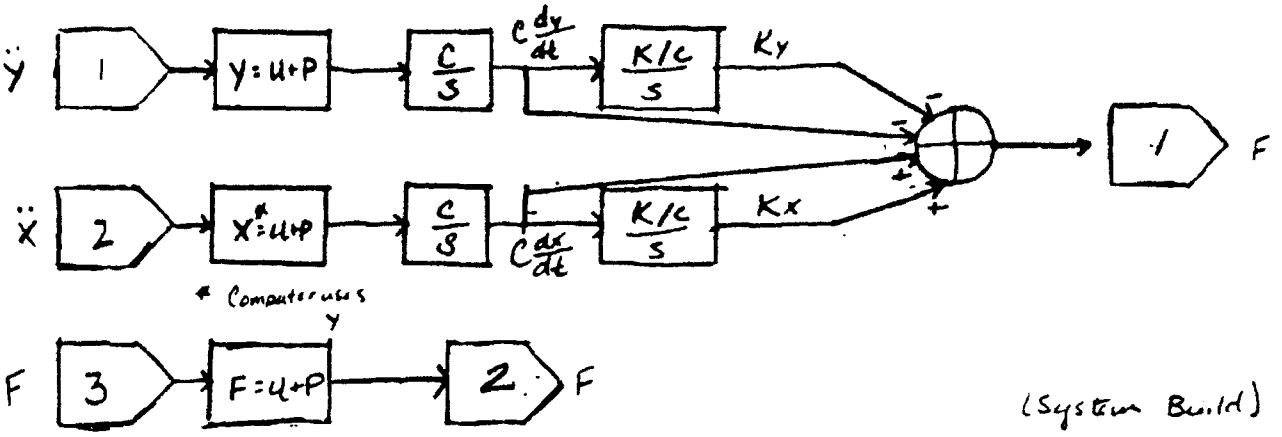


* linear plot of Force v. Δ [illegible]

9 drops = a) 6" w/ 1) short 2) medium 3) long rope
= b) 12" w/ 1, 2, 3
c) 18" w/ 1, 2, 3

$$F = C\left(\frac{dx}{dt} - \frac{dy}{dt}\right) + K(x-y)$$ – use this to check F

C, K = unknown



(System Build)

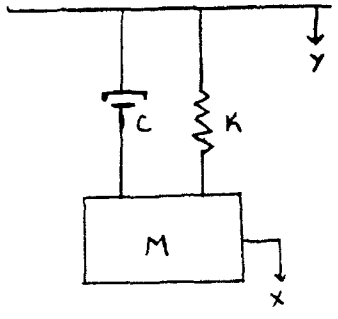
Trial / Error for C, K until graphs from 1+2 = graph 3

3RD Effort

$$-C(\dot{X}-\dot{Y})-K(X-Y)=M\ddot{X}$$

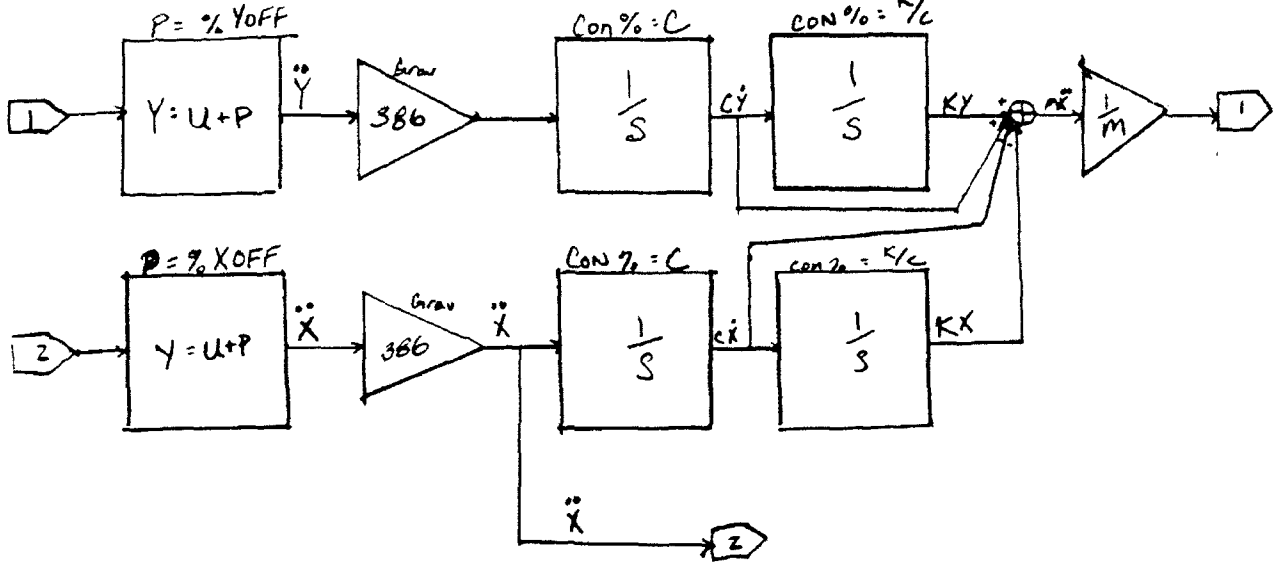
$$M\ddot{X}+C\dot{X}-C\dot{Y}+KX-KY=0$$

$$M\ddot{X}=C\dot{Y}+KY-C\dot{X}-KX$$



Let $\ddot{X}$ = Lead weight Z Axis Acceleration

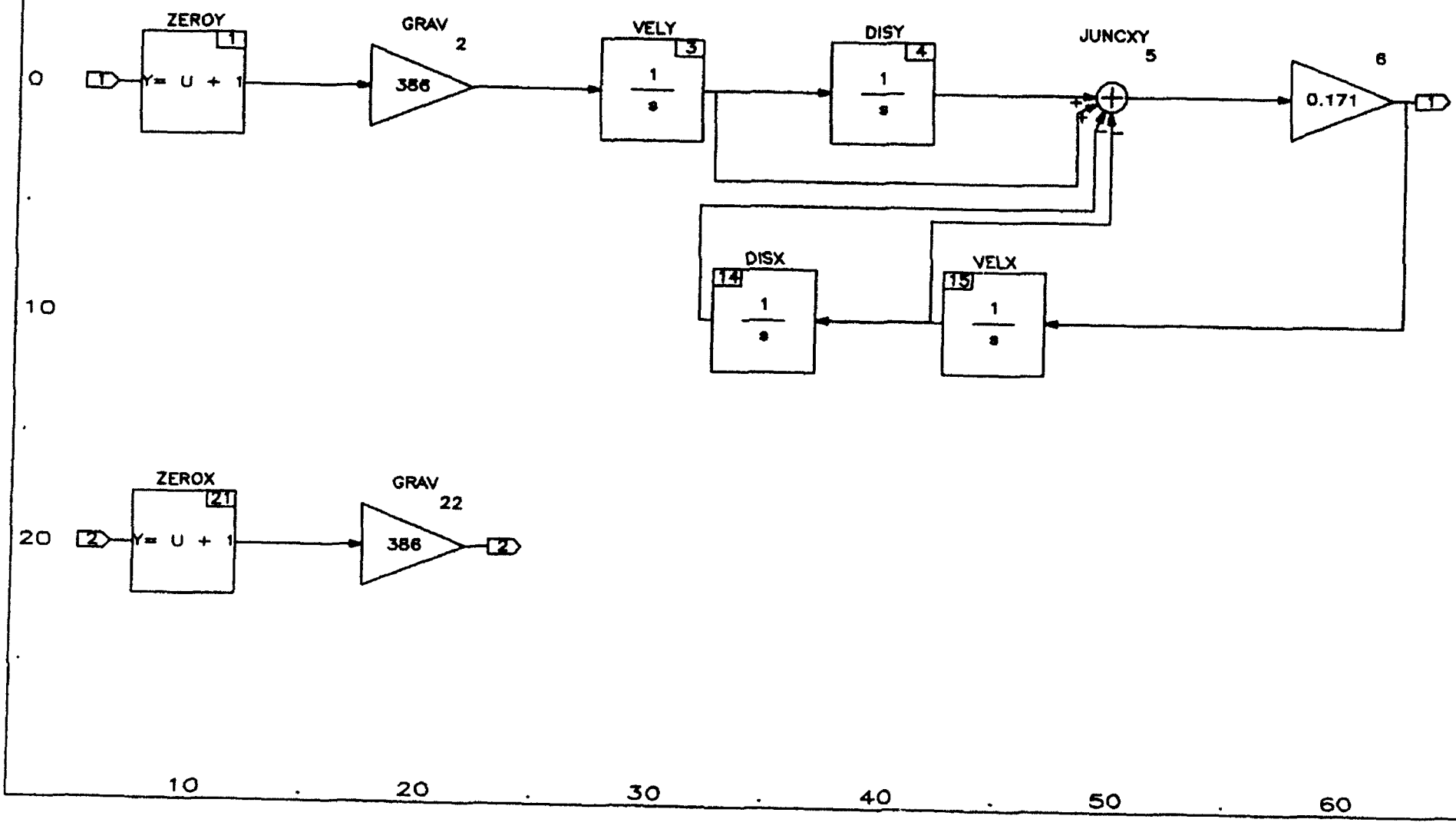
Let $\ddot{Y}$ = Average of Boomerang Z Axis Acceleration



Gs 386 in/sec²

Continuous Super-Block PAR

Ext.In	Ext.Out
2	2



Command File

```
LOAD 'F:\KIM\PAR.MOD'
EXEC ('E:\DSP\KIM\T.DAT')
EXEC ('E:\DSP\KIM\U.DAT')
SC=0
HC=0
FOR I=1:10,...
SC=SC+U(I,1),...
HC=HC+U(I,2),...
END
FFY=(-.1)*SC
FFX=(-.1)*HC
YOFF=[FFY]
XOFF=[FFX]
INQUIRE C "C"
INQUIRE K "K"
N1=[C]
B=K/C
M2=[B]
N3=[C]
M4=[B]
BUILD,ANAL,PAR,Y=SIM(T,U)
PLOT(T,Y)
```

MULTIMEDIA UPGRADE SUGGESTION FOR HRG AND LISTING OF OTHER AREAS STUDIED BY STUDENT

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Final Report for:
Summer Research Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research

August 1992

MULTIMEDIA UPGRADE SUGGESTION FOR HRG AND LISTING OF OTHER AREAS STUDIED BY STUDENT

Benjamin A. Kuperman
Summer Student

Abstract

Rapid changes in computer technology has provided for the development of a new form of presentation, multimedia. Multimedia is a buzzword that refers to the incorporation of audio, video, and/or touch elements into a presentation or training. In an attempt to stay on the cutting edge of computer technology, HRG asked me to do some background research and propose suggestions for acquiring a multimedia system. Following my report on this subject is a listing of the other areas I have learned about or worked with over the past eight weeks.

MULTIMEDIA UPGRADE SUGGESTIONS FOR HRG

Benjamin A. Kuperman

This report is a suggestion for the hardware and/or software necessary in order to upgrade one of HRG's computers into a viable multimedia system. In order to be useful, I feel that the system's abilities would be to produce a full screen, full motion video/audio presentation that could be output to a standard VCR. This would effectively enable HRG to produce an entire presentation on the computer and simply send it as a video tape accompanied by a knowledgeable representative to answer questions. Another possibility exists in that HRG could create an interactive presentation, where the viewer(s) would be able to control what is displayed. In either case, video, audio, graphics, and text need to be able to be blended together.

At the present time, the forerunner in multimedia hardware and software technology is IBM. Currently, IBM has two different systems in terms of multimedia hardware and software. The first setup uses three separate cards, the M-Motion Video Adaptor/A for video playback and audio mix-in, the Video Capture Adaptor/A for the capture of 16 bit true color images from most video sources as well as providing more power to multimedia applications, and the M-Audio Capture and Playback Adaptor/A to capture, digitize, and playback high quality audio. This hardware setup is backed up by M-Control Program/2, a software program designed specifically for

M-Motion Video Adapter/A. This system works only in VGA and has a maximum resolution of 640 pixels X 480 pixels X 2,097,152 colors.

The second setup consists of the Action Media II card with the screen capture option installed. This one card will perform similar functions as the three cards previously mentioned. It also uses a state of the art Digital Video Interactive (DVI) compression system that allows for full screen, real time video to be stored at 9 megabytes per minute. This is a significant improvement over the standard storage of each screen which takes 30 megabytes per second. The compression algorithm is soft coded on the board, allowing it to be updated when an improved version comes out. The Action Media II card is setup is backed by one of two programs, Audio Visual Connection (AVC) for OS/2 platforms and Linkway Live! for DOS. Action Media II works in both VGA and XGA environments.

The M-Control Program/2 provides software "toolkits" that work in OS/2, DOS, or Windows environment. It also allows a tie-in to a standard video disk player to the rest of the M-Motion Video Adapter/A inputs. The program provides for software control over video inputs, windowing, color, hue, brightness, contrast and fading as well as control over audio input, output, volume, tone, and balance. It also provides a gateway for AVC to use the M-Motion Video Adapter/A.

AVC is an OS/2 based authoring language that covers all the

bases for multimedia presentations - graphics, word processing, data processing, and audio editing. The graphics editor allows you to cut-and-paste, zoom, airbrush, rotate, resize, skew, and add text as well as the standard drawing program features. AVC also permits full motion video to be displayed at the same time as text, graphics, or selectable button areas during use. It provides for one-tenth of a second blocks of audio to be edited, as well as rearrangement and mixing of audio tracks.

Linkway Live! operates in a Window-like environment. It uses on screen icons and buttons to control the program. This particular program requires less programming skill but lacks the versatility of AVC.

Regardless of the video and audio boards used, certain hardware elements are necessities to any multimedia system. The first of which is an absolute minimum memory level of four megabytes. I personally feel that the minimum required is six megabytes. A larger amount enhances the overall usefulness of the system. With huge amounts of data requiring disk space, I see three alternatives. The first possibility is an enormously large hard drive. This is impractical in that development is limited to the size of the disk. The second option a removable hard drive that allows a user to switch hard disks. The third solution is a rewritable optical drive that can store 127 megabytes per optical disk. With either of the latter two, disk swapping might become a

difficulty. The best solution seems to be using a hard drive for development and storing the completed project on a rewritable optical disk.

Of course, the technology for multimedia is advancing at a dizzying rate. IBM is expected to announce a major development sometime in October. Other companies are working on similar software authoring languages, as well as hardware devices. At present, I would recommend the Action Media II card for several reasons. First, it requires only one slot on a machine, still allowing for the option of networking and other expansions. Secondly, it possesses the best compression that I have come across. Lastly, it is upgradeable so that an investment in the board would not be made obsolete by new developments. For the authoring language, I would recommend AVC. However, this requires OS/2 and a basic programming knowledge. Keeping this in mind Linkway Live! might be the choice for HRG because of its simpler format. My own suggestion is to purchase AVC and wait for a few other companies to complete their own simplified authoring languages before deciding on anything like Linkway Live!.

Cost Estimates

1.	Action Media II Card	$1,995
2.	Action Media II Capture Option	$ 890
3.	M-Motion Video Adapter/A	$2,250
4.	Video Capture Adapter/A	$2,250
5.	M-Audio Capture/Playback Adapter/A	$ 370
6.	3.5 Inch Rewritable Optical Drive	$1,795
7.	3.5 Inch Rewritable Optical Disk	$ 70
8.	Audio Visual Connection (AVC)	$ 571
9.	Linkway Live!	$ 410
10.	M-Control Program/2	$ 195
11.	Removable Hard Drive (100 meg)	$ 700

LISTING OF OTHER AREAS STUDIED BY STUDENT

Benjamin A. Kuperman

1. Use of technical library for research
2. CD-ROM based periodical search
3. Electronic periodicals
4. Basic operation of a Macintosh computer
5. Differences between EtherNet phase one and phase two
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PROCESSING AND PREPARING A PROTOCOL CASE FOR FINAL PATHOLOGIC ANALYSIS

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Final Report For:
Summer Research Program
Armstrong Laboratory

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PROCESSING AND PREPARING A PROTOCOL CASE FOR FINAL PATHOLOGIC ANALYSIS

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Abstract

The Comparative Pathology Branch consists of three sections: Anatomic Pathology, Clinical Pathology, and Electron Microscopy. Each section plays an important role in processing and preparing specimens for analysis. The Anatomic Pathology section provides necropsy, tissue processing, staining, and microscopic examination. Clinical Pathology performs all diagnostic tests on blood and fecal samples. The Electron Microscopy section provides tissue processing and prepares specimens for the transmission and scanning electron microscopes.

PROCESSING AND PREPARING A PROTOCOL CASE FOR FINAL PATHOLOGIC ANALYSIS

April Marie Lopez

Introduction

Questions concerning man's ability to adjust to future environments are being researched in various studies and experiments. Specimens used in the studies are subjected to specific conditions for specific periods of time. Comparative Pathology uses its own special tools to process and determine what changes have occured in tissue samples submitted by different studies. All three sections of Comparative Pathology- Anatomic Pathology, Clinical Pathology, and Electron Microscopy- work together to reach a final diagnosis.

Methodology

Each case is given an accession number. This number will be used to label all material (blocks, slides, etc.) pretaining to the specimen or in any further reference to the case. The Anatomic Pathology section takes tissue samples and preserves them in formalin. The tissue is kept in formalin for at least twenty-four hours to insure preservation. After this twenty-four hour period, a gross examination is performed. During the gross examination, large tissue samples are reduced in size and placed in cassettes. The cassettes are then put into a tissue processor where they are impregnated with paraffin wax. The tissue is then embedded. This is where the specimens are set in molds filled with hot paraffin wax. The molds are cooled on the cryo console until solid paraffin blocks form. The blocks are then sectioned, one by one, with a microtome. The best section is selected and mounted on a slide. The slides are heated in an oven to melt off the paraffin and dried.

The slides are now ready to be stained. The most common staining procedure used is the Hematoxylin and Eosin (H&E) stain. In this staining procedure,

the slides are initially immersed in Histoclear. Next, is a series of absolute alcohol changes. The slides are then flooded with 95% alcohol. Water is used to rinse the alcohol from the slides and tissue.

After spending six minutes in Hematoxylin, the slides are washed in tap water and quickly dipped in 1% acid-alcohol to remove the excess stain. The slides are washed again in tap water and dipped in saturated Lithium carbonate to enhance the Hematoxylin stain. Another rinse in tap water follows. The final series in the staining procedure includes 95% alcohol, Eosin, absolute alcohol, and Histoclear. Concluding the staining procedure with Histoclear allows cover slips to be mounted easily. The finished slides are labeled and given to the pathologist to be read.

The Clinical Pathology section receives blood and fecal samples. There are several tests performed on each blood sample. Complete Blood Counts (CBC) and Chemistry tests are done on blood samples. A Coulter Counter is used to provide the complete blood counts. Chemistry tests, which are performed on serum, calculate the amount of proteins, enzymes, and cholesterol in the blood. Blood smears are also used along with light microscopes to identify white blood cells.

Cultures are grown from the fecal specimens to detect the presence of parasites. Slides are specially stained to identify Cryptosporidium oocysts. The Cryptosporidium stain highlights the oocysts red while the background stains blue. The slides are examined using a microscope and the results are given to a pathologist along with the results of the blood tests.

The Electron Microscopy section also receives tissue samples. Specimens here are prepared for analysis using the transmission and scanning electron microscopes. Tissue samples received are preserved with Karnovsky's fixative. Karnovsky's fixative is stronger than formalin and only penetrates one

millimeter into the tissue. For this reason, tissue is minced as it is being preserved. The tissue is washed in Sodium cacodylate buffer and immersed in 1% Osmium tetroxide for one hour. At this point, the tissue is dehydrated with graded solutions of ethyl alcohol at fifteen minute intervals. The tissue is sent through three changes of Propylene oxide and placed under vacuum on the last change. The Propylene oxide is removed from the tissue. A 1:1 mixture of plastic, Propylene oxide, and 1.4% DMP (catalyst) is added. The tissue is left in the plastic mixture overnight.

Now, the tissue is embedded in pure plastic and allowed to harden for three days. The hardened blocks are ready to be cut on the microtome. The blocks are first cut at one micron, stained, and given to a pathologist for examination. The pathologist determines which sections have areas that illustrate his diagnosis or will help him diagnose the case. All tissue outside the area of interest (which may only be two or three cells) is trimmed away. Thin sections are cut (600-800 angstroms), placed on copper grids, and examined using the transmission electron microscope by an electron microscopist. At this time, electron micrographs are taken of the specified regions and returned to the pathologist for further analysis.

Conclusions

The results of controlled experiments are interpreted by the Comparative Pathology Branch. This laboratory is the only one of its kind at Brooks Air Force Base. These are the only trained specialists that are capable of processing tissue specimens and interpreting the results of experimental cases. Without its services, many research projects would be incomplete.

A STUDY IN COMPUTER APPLICATION USING WORD PERFECT AND (ORACLE) SPREADSHEET

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August 1992

A STUDY IN COMPUTER APPLICATION USING WORD PERFECT AND (ORACLE) SPREADSHEET

Raul L. Lopez
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Air Quality and Hazardous Waste Branch
Brooks Air Force Base

Abstract

The bioenvironmental engineering division provides environmental support to the Air Force worldwide. Through support ranging from water and waste environmental monotoring to hazard abatement and pollutant control, the division provides expertise extending to virtually all types of toxic or radiological agents found in soil, water, air, and associated ecosystems with potential pathways of human exposure or impact. The division solves these Air Force environmental concerns through professional consultation, specialized laboratory services, applied research or on-site technical support using organizational, host installation, and contractor resources.

A STUDY IN COMPUTER APPLICATION USING WORD PERFECT AND (ORACLE) SPREADSHEET

Raul L. Lopez

INTRODUCTION

In recent years the Brooks Air Force Base Air Quality and Hazardous Waste division has begun to play a more significant role in monotoring and upgrading environmental conditions at installations world wide as a result of legislation such as the 1990 Clean Air Act which has provided more specific guidelines for industrial safety.

In order to maintain an efficient level of labor, I was required to become proficient with several of the many computer programs that were availabel to civilian personnel such as Word Perfect, Oracle, and All In One. Since the majority of my studies here at Brooks involved heavy interaction with the computer and with other people, I picked the system up as quickly as possible. In my brief tenure I was a vital key in dealing with problems involving limited resources and funds, computer system capability boundary dilemmas, and tables involving water sampling elements.

DISCUSSION OF PROBLEMS

As a result of Congress legislation and military budget cuts funds have come to play a more significant role in the services provided by the Bioenvironmental Engineering Directorate here at Brooks. For example, contractors hired by the directorate were granted a given sum of money to conduct a thorough disposal of hazardous waste at an undisclosed installation. After further

investigation, it was concluded that several drums of hazardous waste that were to be disposed, were left behind by the contractor, thus rendering the service unfinished. After several attempts to contact the contractor and alert them of this dilemma failed we were forced to pursue our last option and my first study. I was instructed to search the database and retrieve the file containing all drum serial numbers. Comparisons of actual drums disposed of and data base serial numbers concluded that the contractual breach had cost the directorate considerable amounts of money.

Soon, I had become fully proficient in Word Perfect and was given the task of creating a series of tables that were to be used by the entire water branch for the manipulation of data that were later to be submitted in formal Air Force Wastewater Reports. Evolving into a four week project, this task offered many challenges. Chiefly, no one in the immediate branch was very proficient with the table edit functions that were neccessary to carry out my job. As a result, much of my time was spent coordinating my studies with computer specialists in the surrouding vacinity. Upon completion of the tables, my main concern was to find a way to send the data and tables I had gathered and created to the water branch, making them fully accessible. The fact of the matter was that such an attempt had never been undergone in the past and neither I nor the specialists were certain what results this venture would produce.

Simultaneously, I also took on a project involving research and quantitative analysis. With limited resources available it was to be determined which bases were to receive the required

sampling necessary to determine the condition of the nearby ecosystem. When precipitation occurs, often there is hazardous waste runoff through outfalls which can create potential hazards for nearby plants and animals. After testing the outfalls of these given bases it was necessary to sum up an estimated cost for the services that were to be rendered. Following a series of extensive meetings my mentor and I determined that the best way to approach this, my final project, was to create a spreadsheet. Again, this task involved consultation from computer specialists who trained me to access and operate the ORACLE program. Incorporating a total of approximately thirty bases, forty minerals, and over sixty outfalls worldwide, I began my analysis by researching pamphlets, books, reports and gathering as much data as I could find. Though this project proved to be the most challenging yet, after several weeks my spreadsheet was complete, thus concluding my research.

RESULTS

The outcome of the drum sampling dilemma was undetermined. It was the responsibility of the directorate to pursue the matter further.

Through trial and error it was discovered that there was a possible means of making the tables fully accessible to everyone in the water branch. The tables were a success and are expected to be incorporated into formal Air Force Water Reports immedialely.

The spreadsheet was taken to a higher chain of command in

which proved to be a valuable tool in predicting the estimations of future water sampling costs.

CONCLUSION

The time I have spent here at the Bioenvironmental Engineering Laboratory at Brooks Air Force Base has been very fulfilling in many ways.

When I first arrived here at the laboratory, I was not sure about what to expect. Not having stepped fooot in a military engineering facility before many questions loomed in my mind. Was there going to be strict discipline enforced on me? How well would cope with the work I was to receive? Probably the biggest question I had in my mind was how were the people there going to treat me? Was I just going to be another high school kid there for the summer? I was determined to work as hard as possible to make a good impression on my fellow co-workers. Well, as soon as I arrived I was introduced to everybody in the building and the receiver of warm smiles from every direction. The people I worked with were extremely friendly and cooperative.

Until my employment I had never seen a centrifuge generate two g's of gravitational force. Nor had I known of such a thing as right and left eye dominance. The exposure I received as an RDL apprentice was incredible.

Being hispanic in a virtually total hispanic populated school, I discovered ignorance I did not know I possessed about people of other ethnicities. Here, I was exposed to people of different

cultures and worked for one purpose, the good of the environment. I learned a lot here about many things. I learned a great deal about myself, operating efficiently in a working environment, computers, people, and communication skills, things that you just do not learn and are not exposed to at school. My experience here as an RDL Summer Research Apprentice was an invaluable experience I truly enjoyed and learned from. I would like to thank Research and Develompent Laboratories for offering students, like myself, such a wonderful opportunity to participate in a fine program. Indeed, I look forward to serving RDL again in the future.

(Attatched are examples of tables I created)

TABLE F-9, Results of Total Toxic Organics (TTO) Analyses (Table 1 of 3) BROOKS A.F.B. DATE (All Concentrations in ug/l)		
EPA Method 608		
ANALYTE		
Aldrin		
alpha-BHC		
beta-BHC		
delta-BHC		
gamma-BHC		
Chlordane		
DDD		
DDE		
p,p-DDT		
Dieldrin		
Endosulfan I		
Endosulfan II		
Endosulfan sulfate		
Endrin		
Endrin aldehyde		
Heptachlor		
Heptachlor epoxide		
Toxaphene		
Aroclor 1016		
Aroclor 1221		
Aroclor 1232		
Aroclor 1242		
Aroclor 1248		
Aroclor 1254		
Aroclor 1260		
Endrin Ketone		
Methoxychlor		

TABLE 1
WASTE STREAM CHARACTERIZATION
HOLLOMAN AIR FORCE BASE NEW MEXICO

WASTESTREAM SHOP & BLDG	BASE SAMPLE NO.	DATE SAMPLED	ANALYSIS REQUESTED	MAJOR COMPONENTS	F P (deg F)	R X (mg/kg)	CORR (pH)	T C L P METALS (mg/L)	T C L P VOL (mg/L)	E R TOTAL METALS (mg\L)	T O X

49 OG/MACFC
Corr Control
Bldg 282
Rags, Alodine
	GT921261	23 Jun	TCLP-M	NP	NP	NP	NP	Cd=0.2
								#Cr=85
								Others=ND
									NP	NP	NP

49 CES/DEMEP
Power Pro
Bldg 54
Waste Oil
	GT921262	23 Jun	TCLP
			MC
			HTW
				H2O=96%
				Paint
				Solvent=4%
					>200	ND	7.2	ND	#a=17
									Others=ND
										NP	NP

49 CES/DEMNCA
Paint Shop
Bldg 55
Paint Related
Waste
	GT921263	23 Jun	TCLP
			MC
			HTW
				H2O=33%
				Organic
				Solvent=67%
					*<60	ND	6.3	#Pb=21
								Others=ND
									#g=1900
									Others=ND
										NP	NP

49 Med Grp/SGHR Medical X-Ray Bldg 15 X-Ray Film	GT921264	23 Jun	TCLP-M	NP	NP	NP	NP	ND	NP	NP	NP
49 TRANS/LGTM Allied Trades Bldg 195 Waste Paint	GT921265	23 Jun	TCLP MC HTW								

NOTE 1: SYMBOLS
- * Exceeds TCLP ignitable criteria: 140 deg Fahrenheit (F)
- ** Exceeds ER ignitable criteria: <100 deg
- # Exceeds TCLP limits
- @ Exceeds ER reactivity limits

NOTE 2: ACRONYMS
- TCLP-M: Toxicity Characterisitic Leachate Procedure-Metals
- PHC: Petroleum Hydrocarbons
- TOX: Total Organic Halogens
- SV: Semi-Volitiles
- CORR: corrosivity
- FP: Flash Point
- ND: none detected
- NP: not performed
- ER: energy recovery
- Deg F: degrees fahrenheit
- PPM: parts/million
- Mg/Kg: milligrams per kilograms
- Mg/L: milligrams per liter

The Study of a Personal HSAP Experience Involving Laboratory Technician Work and Observation

Andrew Malone
HSAP Apprentice

Final Report for:
Summer Research Program
Armstrong Laboratory

Sponsored by:
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Wright Patterson Air Force Base, Fairborn, OH

August 1992

A Study of a Personal HSAP Experience Involving Laboratory Technician Work and Observation

Andrew Malone
HSAP Apprentice

Abstract

RDL's HSAP was participated in. The author was allowed to observe a few other laboratories during the course of the program and was assigned a few simple tasks at the focal point laboratory. The lack of a formal project precluded the writing of a more substantial, meaningful report, and it made the overall experience less valuable than it could have been.

A Study of a Personal HSAP Experience Involving Laboratory Technician Work and Observation

Andrew Malone

Introduction

The duration of the eight week tour passed without the assignment of any one specific project. Instead, a few simple tasks related to, but in no way encompassing the whole of, several experiments was assigned. Since knowledge of every intricacy or even the goal of these experiments was not required, these details will not be reported. Gross technical summarization of the execution of each experiment is therefor not indicative of negligence on the part of the author in omitting important aspects of the summer tour.

The author had marginal influence on the execution of the Air Force study titled NO-3. The study's goal was the determination of the effects of ingested Fyrquel hydraulic fluid on the reproductive functions of rats. The author also calibrated equipment for an inhalation experiment to determine the toxicity of a halon-replacement compound (HCFC-123), also in rats.

Observation of other scientists work in other laboratories was a substantial portion of the summer "research" experience. This observation included a tour of a chemistry lab, where the principles of gas chromatography were explained. Observation of

individuals allowed me to become acquainted with the "RS-1" statistical package. A sample graph is included in the Results section.

Methodology

In part of the NO-3 study, 80 female rats are grouped into four categories, each of which receive differing doses of the hydraulic fluid. To detect estrous cycle abnormalities, a vaginal wash is performed on each of these rats everyday for the duration of the experiment (including pre- and post-exposure). This procedure involves the flushing of apx. .07 mL of a saline solution (0.9% sodium chloride; Abbott Labs, N. Chicago, Il) into the vagina by way of a straight-tip pipette. The wash-liquid, now in the pipette, is then placed onto a slide and read by a technician to determine the type and number of cells present in the fluid. This information would later be used to interpret the length of the estrous cycle. The large number of rats tested each day requires the production of large numbers of labeled slides (Erie Scientific, Portsmouth, NH). Labeling these slides and performing some of the vaginal washes was the author's contribution to this study.

An IR spectrometer (Miran CVE, Foxboro Inc.) is the instrument used to measure the concentration of both Halon-replacement compounds and Halothane (Halocarbon Industries, N. Augusta, SC) in the focal-point's laboratory experiments. Halothane

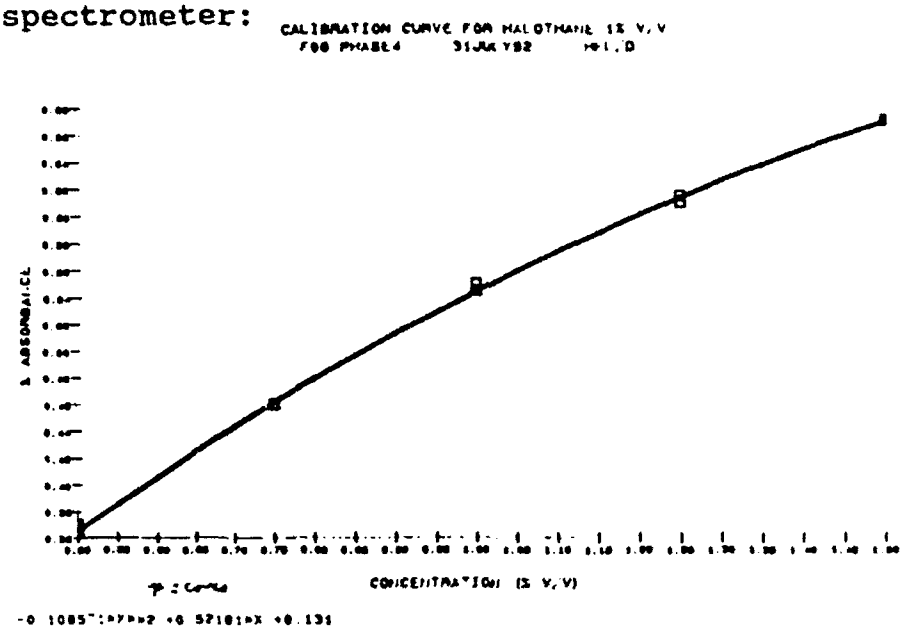
is used as a positive-control chemical in toxicity testing of Halon-replacement compounds. The generation of several bags of known concentration mixtures of Halothane-vapor/air is necessary in order to calibrate the IR spectrometer. These bag mixtures are then fed into the device, which is set to a predetermined wave-length (7.85 micrometers). The spectrometer's output (% absorbance) is then fed into the statistical package "RS-1" and analyzed to determine the relationship "concentration of Halothane vs. % absorbance". Another calibration was done in a similar manner to this one. It was done to calibrate a gas chromatograph in order to detect and control the concentration of PCE (tetrachloroethylene) in the air mixture given to rats in a study. The data is presented in the results section.

Results

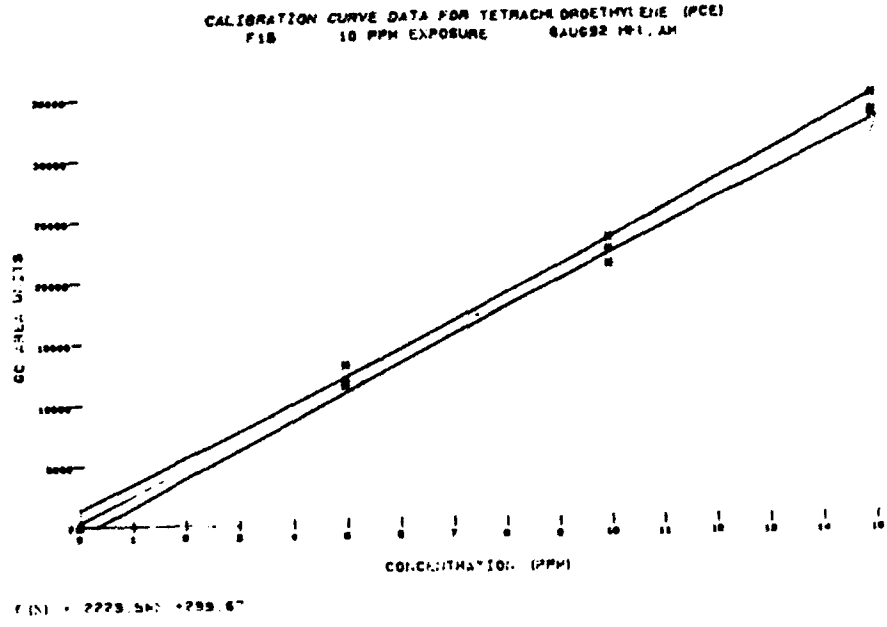
The author's involvement with the mentioned studies was so slight that the reporting of the overall results of these studies would be inappropriate. The data reported here is restricted solely to data generated by the author.

The calibration data that follows was used in the actual experiments that called for the calibrated equipment.

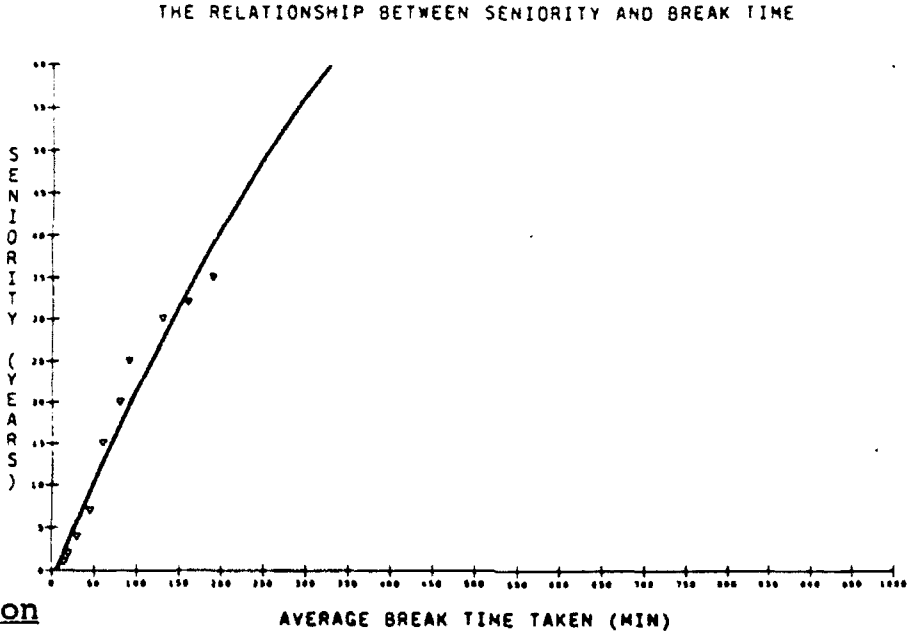
Below is the calibration graph generated for Halothane using the IR spectrometer:



Below is the calibration data for a Varian GC for PCE, accomplished with assistance from another (Harry Leahy):



The following is the product of experimentation on the "RS-1" statistical package. The data, however convincing, is bogus:



Conclusion

The summer tour would have been more effective and exciting if a project involving substantial responsibility had been assigned. Being constantly in search of something to do inevitably led to the apprentice "getting in the way" of others and, eventually, to boredom. Nothing motivates more than responsibility and a certain level of inner guidance. These are what the program lacked, and this lack precluded the author from writing a more formal, "real" scientific research paper.

A Test of Feature Conjunction and Feature Disjunction Tasks in Three Dimensional Space

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Final Report

Summer Research Program

Armstrong Lab

Sponsored By:

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Bolling AFB, Washington D.C.

August 1992

A Test of Feature Conjunction and Feature Disjunction Tasks in Three Dimensional Space.

Virginia Miksch

Both a feature conjunction task and a feature disjunction task were developed in three dimensional space on Silicon Graphics 3130 IRIS computer system and a Hitachi 60-hz color video monitor. Six subjects volunteered to run in the study. The study was two-fold in scope. First, it was conducted to reaffirm Treisman's concept on the serial process, and secondly, to prove or disprove Previc's hypothesis regarding the preattentive task also as a muted serial process. Both Treisman's concept and Previc's hypothesis were confirmed. But further studies must be conducted on a greater scale to prove Previc's hypothesis.

INTRODUCTION

Imagine you were shown a photograph of multi-colored and multi-sized books and were asked to locate the big blue book in the picture. Chances are if the book was located in the upper right corner you would identify it quicker than if it was in the lower portion of the screen. The locating of the target shape during this task is referred to as a feature conjunction task. This particular task, according to Treisman, uses focal attention, that is, it is a serial process. You would locate the target faster with only three distractors in comparison to six distractors. The distractors in this task vary in both shape and size.

If you were asked to perform the same task, but with a photograph showing only two sizes of books, you would most likely locate the correct book at about the same time no matter where the target book was on the photo. This task is referred to as a feature disjunction task. The feature disjunction task is a preattentive mode. This means it has one type of distractor that has only one characteristic that makes it different from the target, in this case the characteristic is size. It uses a parallel processing type. The observer scans the photo in a global manner. Previc has proposed that the feature disjunction task uses serial processing in a muted manner.

The purpose of the following study is two-fold: first, to reaffirm Treisman's concept on the feature conjunction task, and secondly, to test Previc's hypothesis regarding the feature disjunction task.

METHOD

Subjects

Six employees at Brooks Air Force Base volunteered to be subjects. The subjects were able to see depth and they were also right-handed, although right-handedness was not a requirement. The subjects consisted of three females and three males. They had a mean age of 30.

Procedure

Each of the six subjects were screened to see if they were able to see depth. The subjects then came for two 1-hour sessions.

The following instructions were given to the subjects at the beginning of each session and any questions they had were answered at this time.

Adjust the chair and chin rest to a comfortable height.

Fixate on the center of the screen.

A warning cross will appear followed by a BRIEF presentation of the target stimulus, a small square, a small diamond, a large square, a large diamond. The target stimulus will be followed by a search field, a screen divided into four quadrants displaying many shapes.

Your task is to search for the target stimulus among the shapes in the search field. When you find the target, press the left button on the RIGHT mouse with your index finger.

After you have responded that you found the target, a screen showing four empty quadrants will appear with a pointer. With the LEFT mouse, move the pointer to the quadrant where the target appeared and click the button.

You will have three seconds to search for the target in the search field. If you don't respond by the time three seconds have passed, the screen will go blank and move on to the next trial. If you respond in time you will have two seconds to move the pointer to the quadrant. If the two seconds expire, the screen will go blank and move on to the next trial.

If you require a break for whatever reason, you may pause the program by pressing the right button in the LEFT mouse, labeled PAUSE. You may only press the pause button between trials while the circle is on the screen.

Your responses must be made as quickly and as accurately as possible.

After the instructions were explained each subject performed three practice sessions, each trial consisting of 144 trials. The first having half at zero distractors and the other half at three distractors, second having six distractors, and the third having nine distractors. The subjects were then asked if they felt comfortable with performing the task and if they could identify the shapes on the screen.

The order of the trials were randomized, three subjects started with the feature conjunction and three started with the feature disjunction.

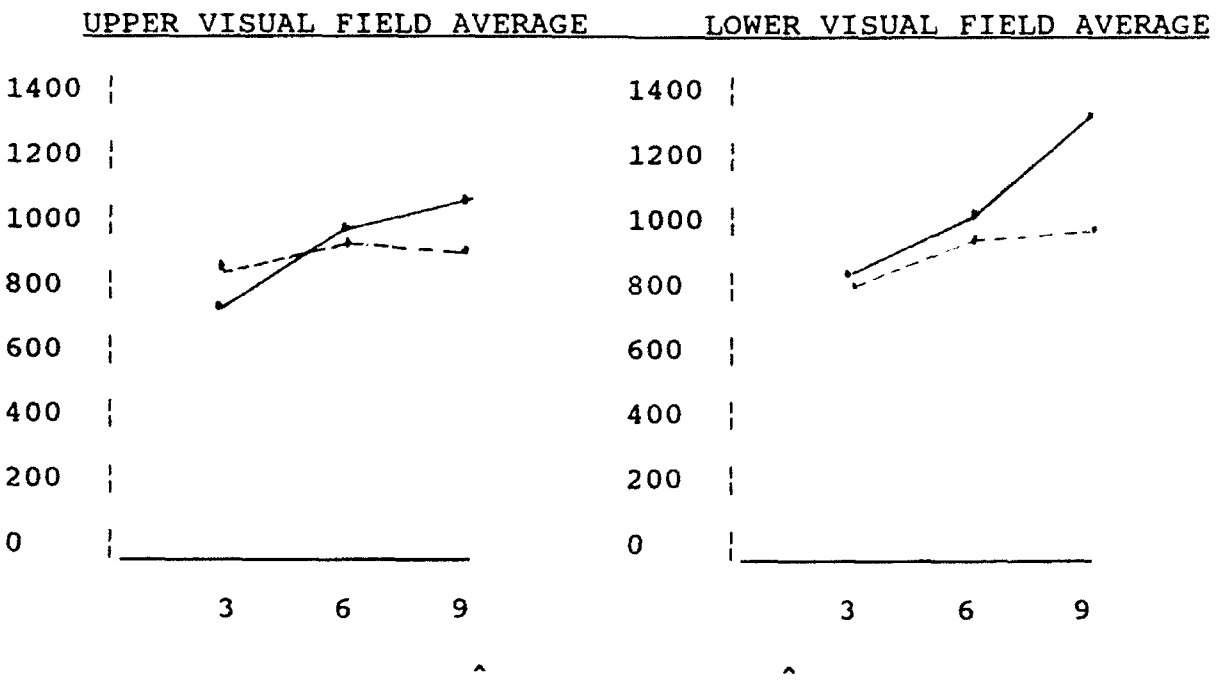
RESULTS

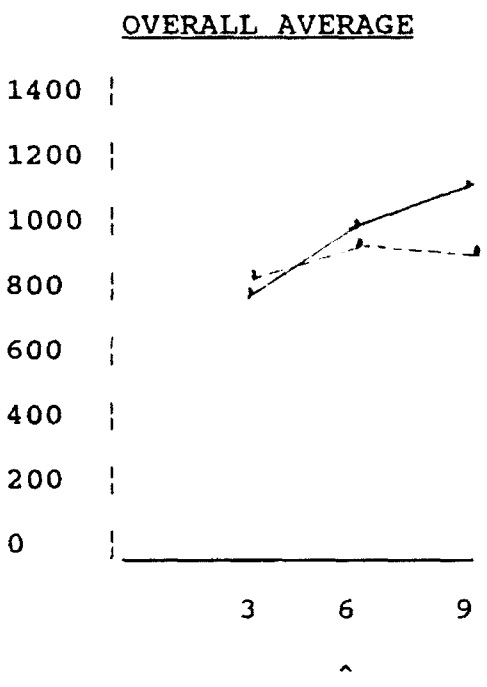
From this study it was found that an increase in the number of distractors caused an increase in reaction time for the upper visual field both during the feature conjunction and feature disjunction tasks.

There was a significant change in the difference between the upper and lower averages during both tasks.

The feature conjunction task increased from a difference of 56 milliseconds, at three distractors, and 54, at six distractors, to 142 milliseconds, at nine distractors.

The following graphs illustrate that a serial process was found in both the feature conjunction task and the feature disjunction task. A serial process is shown on the graph by the fact that as the number of distractors increase the reaction time also increases proportionally.





CONCLUSIONS

From this study, it can be drawn that during a feature disjunction task, a slight serial process can be detected. This raises the greater question regarding a pilot's focus in the visual field. Treisman's original concept was reaffirmed. A serial process did occur during the feature conjunction task. Also Previc's hypothesis was justified, although further studies must be conducted with a greater range of subjects.

If pilot's scan the upper visual field more effectively, then further analysis should be conducted concerning the effectiveness of current HUD systems and how they can be developed to strengthen the pilot's weaknesses.

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INVESTIGATION OF ITEM FACETS FOR THREE WORKING MEMORY TESTS

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INVESTIGATION OF ITEM FACETS FOR THREE WORKING MEMORY TESTS

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ABSTRACT

Items in many cognitive tests are described by facets which may influence item difficulty. A preliminary item facet analysis was conducted on three working memory tests. One test was a numeric based test, one was a verbal test, and one was an alphabet test. Seven item facets were investigated. In general, the item facets determined item difficulties as expected. It was concluded that for these three tests it is possible to make harder or easier tests by developing items through using facets.

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INVESTIGATION OF ITEM FACETS FOR THREE WORKING MEMORY TESTS

Rebecca C. Mortis

INTRODUCTION

Item difficulties have proved to be important in test development. As early as 1905 Binet and Simon used item difficulties to order the items on their scale for measuring intelligence. They placed the easiest items first on the test and the items increased in difficulty as the test progressed (Anastasi, 1976). This early example typifies one way in which psychologists today use item difficulties, to help them position test items in order of increasing difficulty. Modern psychologists also use item difficulties when they are making parallel tests. In order for a test to be truly parallel, the maker of the test must be sure that the items on the tests are of the same difficulty and can be used as parallel items. Psychologists also use item difficulties to make sure that there is a complete range of easier and harder items on their tests. It is important to have a range of items on a test because it makes the test a much more reliable measure. For most testing purposes, the difficulty of an item is defined as the percentage of persons who answer it correctly. The easier the item, the larger this percentage will be.

When psychologists look at item difficulties, they also exam the facets of the item that can make it more or less difficult. Knowing what the facets of items are and how the facets affect the difficulties of the items is beneficial to psychologists and test makers because it allows them to write test items so that they can know in advance which items will be more difficult than others.

The tests and the item difficulty data for the present study were obtained from a program at the Armstrong (Human Resources) Laboratory. This program is trying to identify the cognitive processes underlying human learning. Examples of these cognitive processes include working memory, processing speed, and long-term memory. Computer tests have been developed to measure these cognitive processes in the verbal, quantitative and spatial domains.

I am going to look at three of the working memory tests from this program in order to provide preliminary analyses of the effectiveness of the predetermined facets for setting item difficulties.

METHODOLOGY

TESTS

WMQ4. This a working memory quantitative test of continuous opposites. In this test subjects are required to remember the last three digits and/or their opposites (from ten) in a presented list of numbers without knowing what the total number of digits per list will be in each list. The digits are individually presented in a box located at the top of the screen. After the last digit in a list is presented the subjects are instructed to type in the corresponding numbers of the last 3 digits in that list in their original presentation order. When numbers are printed in white, the subjects are instructed to remember the last three digits exactly as they were printed (e.g., if the list was "6,4,9,2," the correct response would be "4,9,2"). When the numbers are printed in red,

the opposites of the last three printed digits should be memorized. The "opposite" of a printed number is defined as the number resulting from subtracting the printed number from 10 [e.g., using the previous list of numbers (except in red) would make the correct response: 6,1,8]. Some of the lists of numbers contain both white and red digits. The number of digits can range from 3 to 6 digits per list. The subjects are allowed 25 seconds to recall the last three digits and/or their opposites and type in their response. After the subject types the third digit in his/her response, he/she is told whether the answer was correct. The "Get Ready" warning message appears in the box and the next list of digits are then presented. The stimuli consist of the numbers 1 through 9, excluding 5. This test is made up of 16 items with one item being one complete list of digits. (Shute, in press)

The facets of the Working Memory Quantitative Test are the number of digits in each string (from 3 to 6 digits per string) and the number of digits in each string that require the subjects to take the digits opposite from ten.

I hypothesize that the more digits there are in a string the harder the item will be. Therefore, the string with 3 digits in it will be easier than a string of digits with only 6 digits. This is because the more digits in a string, the heavier the memory load which requires the subject to put forth more mental effort to reach the correct response.

For a fixed string size (3,4,5, or 6 digits), the digits to be complemented from ten had only two levels, therefore, this facet is divided into only two levels labeled fewer and more. I hypothesize that the level with fewer complements in it will be easier than the level with more complements in it. When the subject is required to take more complements, the subject must think harder which increases the working memory load.

WMV1. This working memory verbal test consists of a four-term ordering of key words in the furniture and animal categories. In this test, subjects are required to correctly order four key words, according to the relationship described in three sentences. Two of the sentences describe the order in which a pair of key words are to appear within their separate categories (furniture or animals). The third sentence describes the sequence of the categories. Each statement is individually presented at the top of the screen. The subjects determine word order as the statements appear. Below is an example:

> The ANIMALS come before the FURNITURE.
> The bird does not come after the horse.
> The rug does not come before the chair.

The key words (e.g., bird, horse, rug, chair) are coded a different color from the rest of the sentence, and these words will match the color of its category name (i.e., the words "ANIMALS," "bird", and "horse" are one color; the words 'FURNITURE", "rug," and "chair" are a second color). The correct response to this problem would be: bird, horse, chair, rug. The first sentence requires the two animals to precede the two pieces of furniture. The second sentence specifies that "horse" will follow "bird," and the third sentence specifies that "chair" shall appear before "rug." The space where the sentences will appear is marked by three warning asterisks. After all three sentences have been shown, eight numbered alternative responses appear on the screen along with a timer ar the top of the screen. These alternatives consist of all possible sequences of the words using these descriptions. Subjects are allowed 15 seconds to select one

of the numbered responses; after which they are told if it was the correct response. With incorrect responses, subjects are given the option to review the three sentences and alternative responses to understand why they got it wrong. This test contains 24 items, with a choice of eight alternative responses (i.e., the 1-8 keys). (Shute in press)

The facets for the Working Memory Verbal Test are the position of the "Animal vs Furniture" statement (either the first or last sentence in the presentation) and the amount of negatives (does not come before, does not come after) in the presentation of sentences (either 1 or 2).

I hypothesize that the item will be easier when the "Animal vs Furniture" statement is the first sentence in the presentation, as opposed to being presented last. When the "Animal vs Furniture" or category statement is presented first, the subjects can create positions for these two categories in their working (or short-term) memory and then slip the key words into place as they are presented later. When the "Animals vs Furniture" statement is presented last, it requires the subjects to switch the categories and the key words at the same time.

I hypothesize that the item will be easier when there is only one negative in the presentation, as opposed to 2 negatives, which would make the item harder. When there is only one negative, the majority of the directions in the presentation are more straight forward and require less reasoning on the subject's part than when the majority of the directions in the presentation require the subject to think harder and more carefully about what he is supposed to do.

Alpha-WM. This test of working memory involves alphabet recoding. In this test, subjects must memorize a string of non-adjacent letters (from 1 to 3 letters) and then add or subtract 0,1,2, or 3 places in the alphabet to get the correct response for each item. Subjects are first warned to get ready and then a string or nonadjacent letters are shown on the screen one at a time at the rate of one letter per second. After the entire string of letters has been shown a number ranging from -3 to 3 appears in the center of the display. This instructs the subjects to go forward or backward in the alphabet to find a new letter for each of the original letters according to the number that was presented. For example, if the letters G, B, Q were presented with a + 2, the subject would have to find 3 new letters that were two positions later in the alphabet (I, D, S). After the entire problem was shown, a screen was displayed with a timer at the top of it, giving the subjects fifteen seconds to decide on the right response. After these fifteen seconds were up, the screen displayed the sentence "A quick brown fox jumped over the lazy dog" with each letter in a box from which the subjects had another fifteen seconds to choose the correct response using a computer mouse. The subjects were told how many letters in their response were correct. There were twenty-four items in this test.

The facets of the Alphabet Working Memory Test are the number of letters in each string (from one to 3 letters), whether the directions require the subject to move forward ("+") or backward "-" in the alphabet, and the amount of displacement of the letters (0,1,2, or 3).

I hypothesize that the fewer the letters in the string, the easier the item will be. So, a one-letter string would be easiest for the subject and a 3 letter string would be the hardest. When there are fewer letters in the string, the working memory load is not as great and the subjects are not required to put forth as much mental effort to answer the item.

I hypothesize that it would be easier for the subjects when they are given "+" direction, requiring them to move forward in the alphabet, and harder when they are given "-" directions, requiring them to move backwards in the alphabet. When the subjects are given "+" directions they can remember the alphabet in the natural order, from A to Z, and their memories don't have to work as hard. With "-" directions, the subjects must remember in the opposite direction that they are used to, so think harder before they reach the right answer.

I hypothesize that the less displacement the item asks for, the easier the item will be. So, when the item asks for a displacement of zero, it will be easier than a displacement of three. This is because the less displacement there is, the less of a memory load there is and not as much mental effort must be made.

Data Collection

WMQ4/WMV1. For the Working Memory Quantitative and Working Memory Verbal Tests, there were 377 subjects and 385 subjects, respectively, who completed these studies. Each subject participated for seven days (45 hours total). All subjects were high school graduates (or the equivalent) with a mean age of 22 and an age range from 18 to 28. The subjects were civilians that were obtained from two local temporary employment agencies. All subjects were paid for their participation in this study.

The subjects were tested in groups of 15-20 at Lackland AFB, TX. They occupied individual testing stations. Instructions, testing, and feedback were all computer administered with proctors available to answer questions. The tests were administered on Z248 computers with standard keyboards. (Shute 1992)

Alpha-WM

There were 92 subjects who completed the Alpha-Working Memory Test. This test was given to airmen on their eleventh day of basic training during a 3 1/2 hour battery of tests. All subjects were high school graduates (or the equivalent) with a mean age of 22 and an age range from 18 to 28.

The subjects were tested in groups of 45 to 50 subjects at Lackland AFB, TX. They occupied individual testing stations. Instructions, testing and feedback were all computer administered with proctors available to answer questions. The tests were administered on Z298 computers with mice.

RESULTS & DISCUSSION

Table 1. Analysis of Item Difficulties for Two Facets of Working Memory Quantitative Test[a]

Amount of Complements	NUMBER OF DIGITS 3	4	5	6	Row Total[b]
Fewer	.91	.76	.65	.65	.74
More	.81	.73	.65	.48	.66
Column Total	.83	.75	.65	.53	

a. N=377
b. Row Total averages were weighted to make the number of items equal for each row condition.

Table 1 provides the item difficulties for the facets for the Working Memory Quantitative Test. It was hypothesized that as the number of digits increased (from 3 to 6), the item would become harder. The column total for 3 digits per string was .83, meaning that on average 83% of the subjects answered the items with 3-digit strings correctly. The column total for the 6-digit string was .53, indicating that an average of 53% of the subjects answered those items with 6-digit strings correctly. These results proved this hypothesis to be true.

It was also hypothesized that the fewer complements there were in a string the easier the item would be. The row total for fewer complements was .74 indicating that 74% of the subjects answered those items with fewer complements per string correctly. The row total for more complements per string is .66, meaning that 66% of the subjects tested answered these items with more complements per string correctly. This hypothesis was also shown to hold.

Table 2. Analysis of Item Difficulties for Two Facets of Working Memory Verbal Test[a]

Position of Category Statement	NUMBER OF NEGATIVES 1	2	Row Total
First	.68	.61	.65
Last	.67	.61	.64
Column Total	.68	.61	

a. N=385

Table 2 provides the item difficulties for the two facets of Working Memory Verbal Test. It was hypothesized that as the number of negatives in each item increased from one to two, the item would become harder. The results shown in this table prove this hypothesis to be true as the column total for one negative per item shows that 68% of the subjects answered this type of item correctly and the column total for two negatives per item shows that only 61% of the subjects answered this type of item correctly.

It was also hypothesized that if the "Animal vs Furniture" statement came first in the presentation, the item would be easier than if the "Animal vs Furniture" statement was presented last. The results show that there was no significant change of the item difficulty between the positions of the "Animal vs Furniture" statement. Therefore, the position of the "Animal vs Furniture" statement does not make the item any harder or easier.

Table 3. Analysis of Item Difficulties for "Plus" versus "Minus" Instructions for Alphabet Working Memory Test[a]

Direction	Number of Letters			Row
	1	2	3	Total
Plus	.94	.86	.76	.85
Minus	.84	.71	.65	.73
Column Total	.89	.78	.71	

a. N=92

Table 3 provides the item difficulties for two facets of the Alphabet Working Memory Test. It was hypothesized that as the number of letters increases the harder the items will become. The column total for one-letter strings showed that 89% of the subjects answered this type of item correctly, as opposed to the 71% of the subjects who answered the 3-letter string items correctly. This clearly shows that as the number of letters per item increases, so does the difficulty of that item.

It was also hypothesized that an item that required a subject to move in a plus direction in the alphabet would be easier than an item that required a subject to move in a minus direction in the alphabet (85%) of the subjects answered plus direction items correctly as opposed to the 73% of the subjects who answered the minus direction items correctly. This also clearly shows that items with plus directions are easier than items with minus directions.

Figure 1. Average Item Difficulties for "Plus" Instructions For Alphabet Working Memory Test

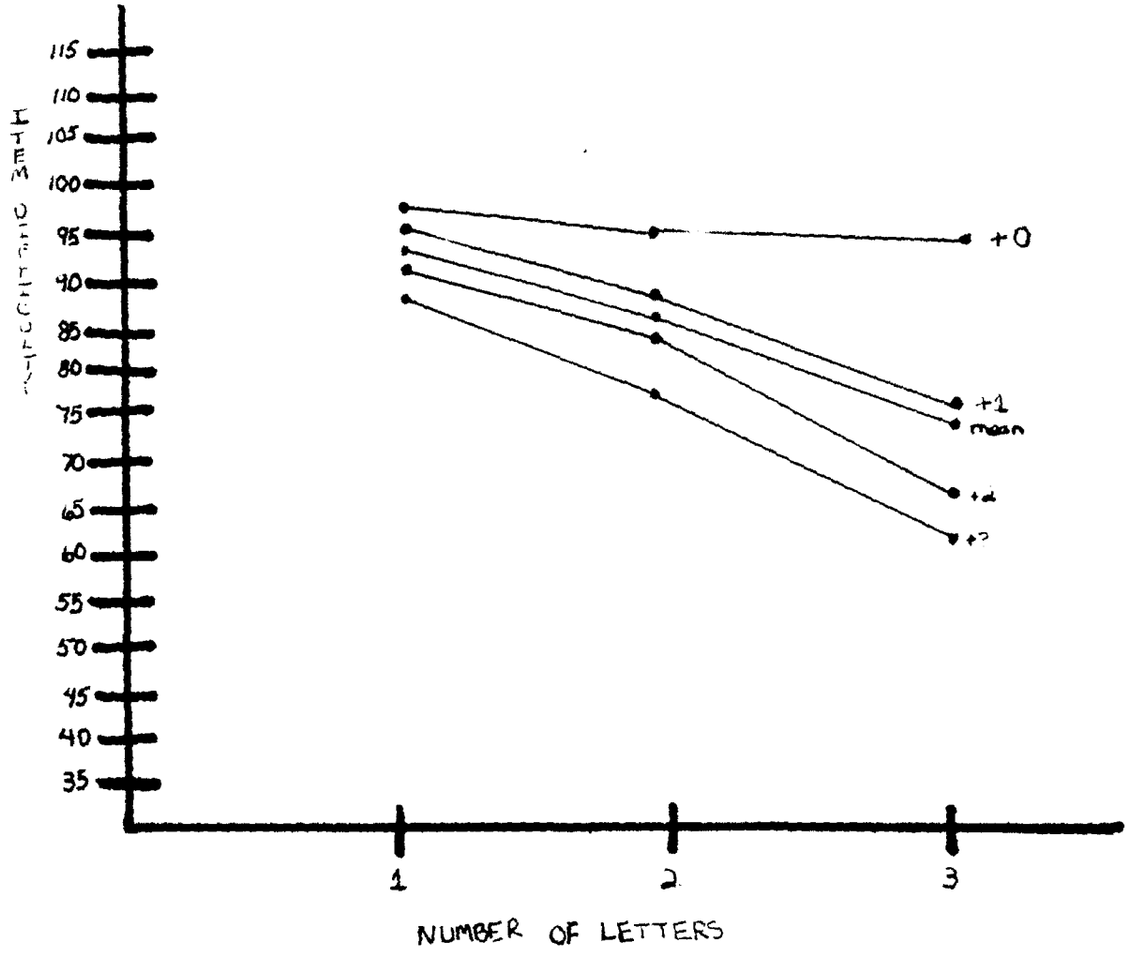

Figure 1 provides the item difficulties for the "Plus" instructions for the Alphabet Working Memeory Test. When there is no displacement (+0) the number of letters has little effect on the hardness of the item. The results may have been different if the number of letters in each string had increased to seven or eight. As the displacement increases from "+0" to "+3", the item becomes harder regardless of the number of letters per string.

Figure 2. Average Item Difficulties for "Minus" Instructions For Alphabet Working Memory Test

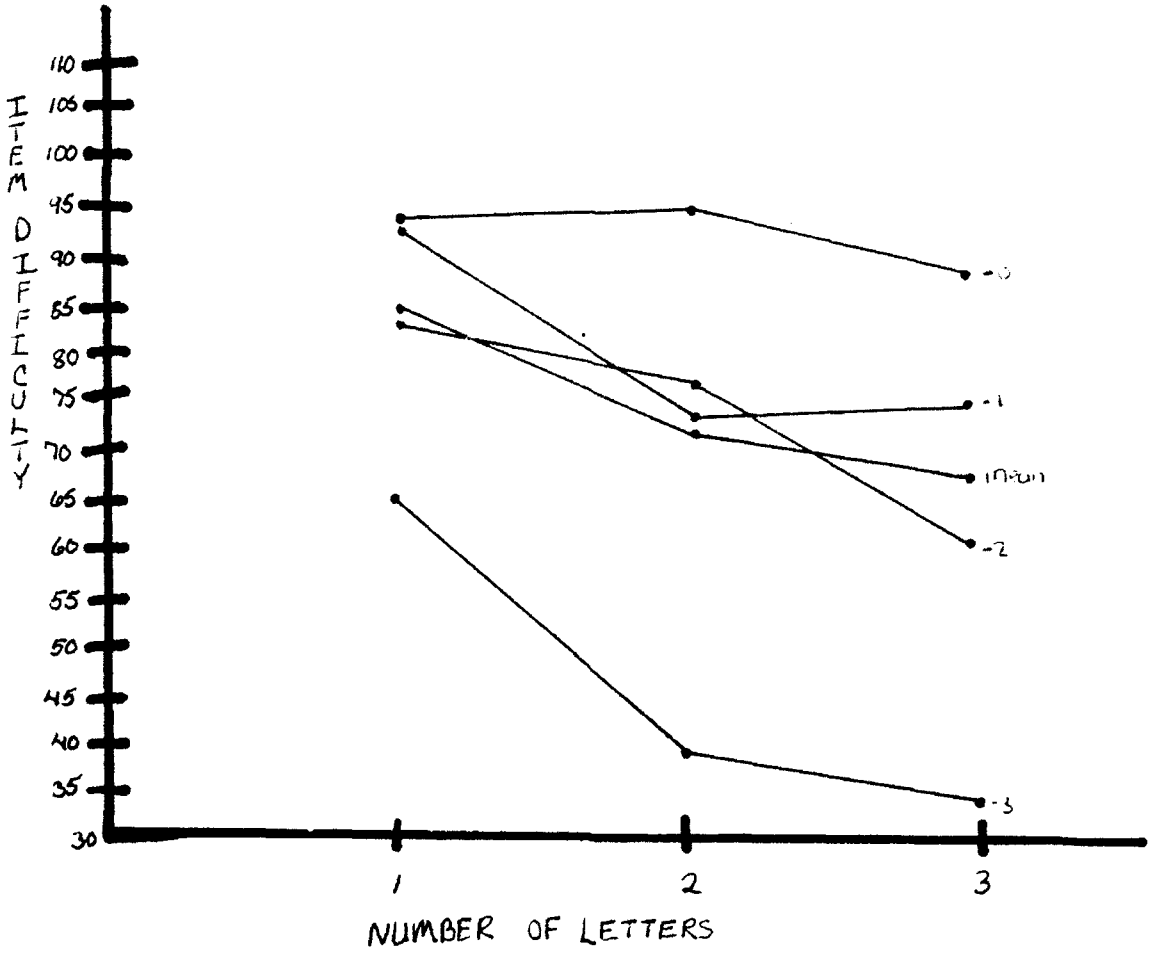

Figure 2 provides the analysis of the item difficulties for the "Minus" instructions for the Alphabet Working Test. When there is no displacement (-0) the number of letters per string has little effect on the difficulty of the item. As the amount of displacement increases from "-0" to "-3" the items get harder regardless of the number of letters per string.

CONCLUSION

In general, the item facets determined item difficulties as expected. The most notable exception was found in the Working Memory Verbal Test in which it was hypothesized that knowing which ordered pair (animal or furniture) would come first should make it easier to learn the animal and furniture key words and thus make the item easier. The data showed no difference between knowing this ordering in advance or learning it after the pairs of key words were memorized. The only other small finding was that the number of letters in the Alphabet Working Memory Test had little effect on the difficulty of the item when there was no displacement. However, the number of letters increased difficulty for all cases where the displacement was one or greater.

This investigation shows that for the three tests it is possible to make harder or easier tests by developing items through use of facets.

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SEE REPORT NO. 17 IN THIS VOLUME
FOR COMPLETE TEXT OF THIS REPORT.

THE USE OF COMPUTER TOOLS AND SEMANTIC NETWORKS FOR KNOWLEDGE ACQUISITION

Margaret J. Hahn
Michael S. Nancarrow

Final Report For
AFOSR Summer Research Program
Armstrong Laboratory

Sponsored by
Air Force Office of Scientific Research
Bolling Air Force Base, Washington, D.C.

August 1992

THE USE OF COMPUTER TOOLS AND SEMANTIC NETWORKS FOR KNOWLEDGE ACQUISITION

Margaret I. Hahn
Michael S. Nancarrow

Abstract

Various tools exist for the aquisition and organization of knowledge, including a process known as concept mapping. Concept mapping was used to organize and interpret data concerning human factors engineering, electronic interfaces, and collaborative processes. Two different computer tools were used to organize and analyze the composite data. Because one tool was still in the design phase, researchers also served as troubleshooters and constructed a user's guide for the tool.

SEE REPORT NO. 5 IN THIS VOLUME
FOR COMPLETE TEXT OF THIS REPORT.

STUDY OF RADIATION AND ENVIRONMENTAL MONITORING PROCEDURES

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Department of Radioanalytical Services

Final Report for:
AFOSR Summer Research Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
Brooks Air Force Base, San Antonio, Tx.

August 1992

STUDY OF RADIATION AND ENVIRONMENTAL MONITORING PROCEDURES

Maria A. De la Cruz
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Abstract

The preparation and analysis of environmental potable and non-potable water samples for the presence of radiation was studied. To prepare the water samples, they are treated with 8N nitric acid and sit for at least 18 hours. They are dehydrated under infrared lamps and a sediment of 200ml of sample is taken and placed in a planchet. The sediment is analyzed for emitted alpha particles in the MICRAD. If beta particles or gamma rays are thought to be emitted, the sample is also analyzed for these.

A STUDY OF THE BAYESIAN ANALYSIS OF RISK DIFFERENCE

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Final Report for :

Summer Research Program

Armstrong Laboratory

Human Systems Center

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Bolling Air Force Base, Washington, D.C.

August 1992

A STUDY OF THE BAYESIAN ANALYSIS OF RISK DIFFERENCE

Robert J. Roche

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Abstract

The Bayesian Analysis of a two by two table assuming Uniform, Constrained, and Beta prior risk difference distributions was studied. In order to compare the density and distribution function, a program was developed that would plot and calculate the density and distribution for any given input of a two by two table. The table represents samples from two binary populations. The density and distribution parameters are determined by this two by two table. The program was written in Fortran 77 and produced an output file for a Calcomp 1044 GT pen plotter. The program calculations indicate a plot of the density and distribution versus delta, the risk difference.

A STUDY OF THE BAYESIAN ANALYSIS OF RISK DIFFERENCE

Robert J. Roche

INTRODUCTION

Throughout the Vietnam War, Agent Orange was used to destroy forest foliage. The components of Agent Orange were required to be thoroughly mixed and spread over most of North Vietnam. In 1978, a study began to explain whether or not the dioxin found in Agent Orange has any harmful effcts. The dioxin used in the Agent Orange substance was thought to act as a poison to animals and people. After many years, researchers have found that exposure to this harmful dioxin is associated with diabetes prevalence among the people who physically handled the Agent Orange. Questions are still being raised today about to what extent did the dioxin affect these peoples' lives. This study became known as Project Ranch Hand II and later as the Air Force Health Study.

Methodology

Various types of methods can be used to explain what effect a specific disease, such as dioxin, has on people who are exposed and people who are not exposed, or controlled. The data is in the form of a two by two table,

i1	n1
i2	n2

where i1 is the number of events in population 1 of size n1, and i2 is the number of events in population 2 of size n2. Two methode that are commonly

used to study this two by two table are risk ratio, or relative risk, and the odds ratio. Another method is the risk difference — the difference in incidence between two populations. This study concerns the integrands used to get Bayesian estimates of confidence intervals for risk difference. I was asked to write a program to plot the density and distribution for Uniform, Constrained, and Beta prior assumptions. The output from this program was used to verify that the density and distribution were correct for use in confidence interval programs.

Application

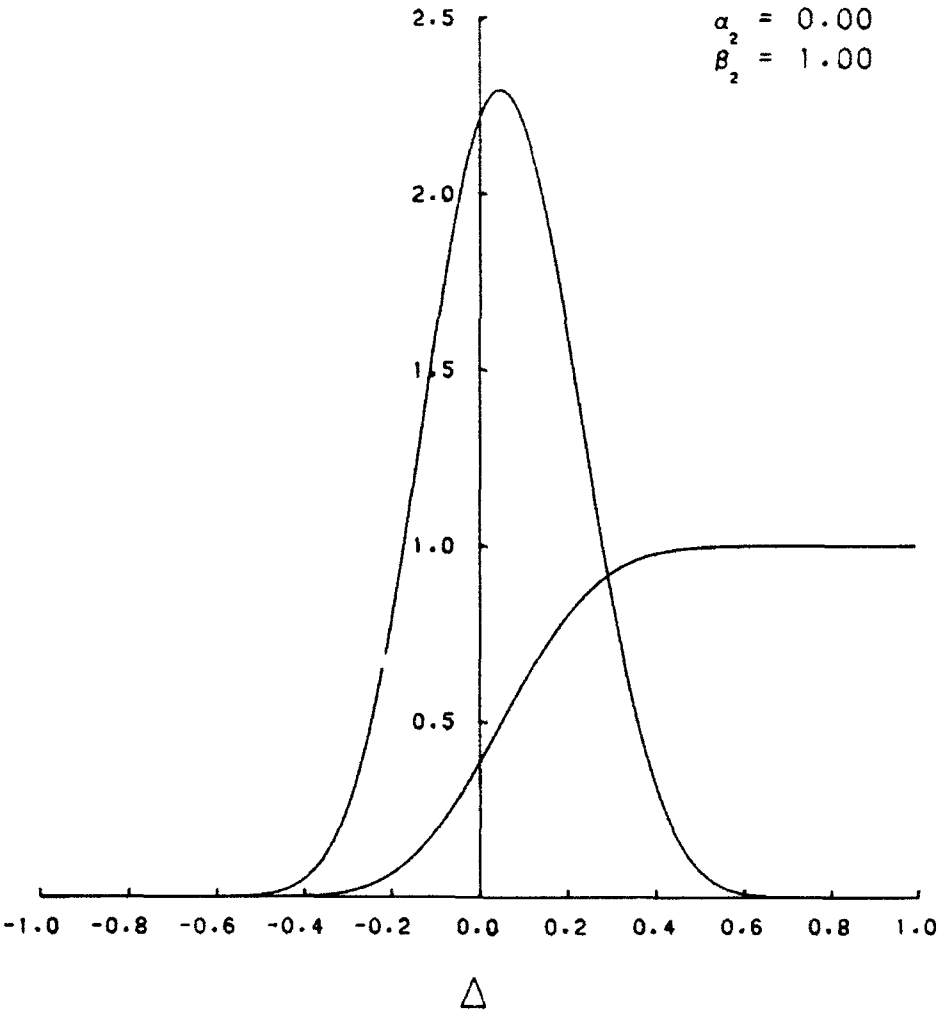
The risk difference method was applied to calculate and plot examples of real population data. Risk difference can be computed with three Bayesian prior assumptions — Uniform, Consrained, and Beta. The integrands for density and distribution for Uniform and Beta priors are over the range from 0 to 1. For the Constrained priors, only a part of the unit interval is used. The parameters in the integrands are determined by the data in the two by two table and the density and distribution are plotted as functions of risk difference. Differences in these functions can easily be seen from the plots.

Example

To test whether or not my program written to calculate and plot Uniform, Constrained, and Beta prior risk difference was acceptable, I created an experimental table. The experimental table was data used to show any calculation errors and trouble-shoot the program for mistakes. The two by two experimental table was entered as 4, 7, 10, 20, where 4 is i1, 7 is i2, 10 is n1, and 20 is n2. The following five graphs are examples of the output related to Uniform, Constrained, and Beta prior risk difference for the experimental table.

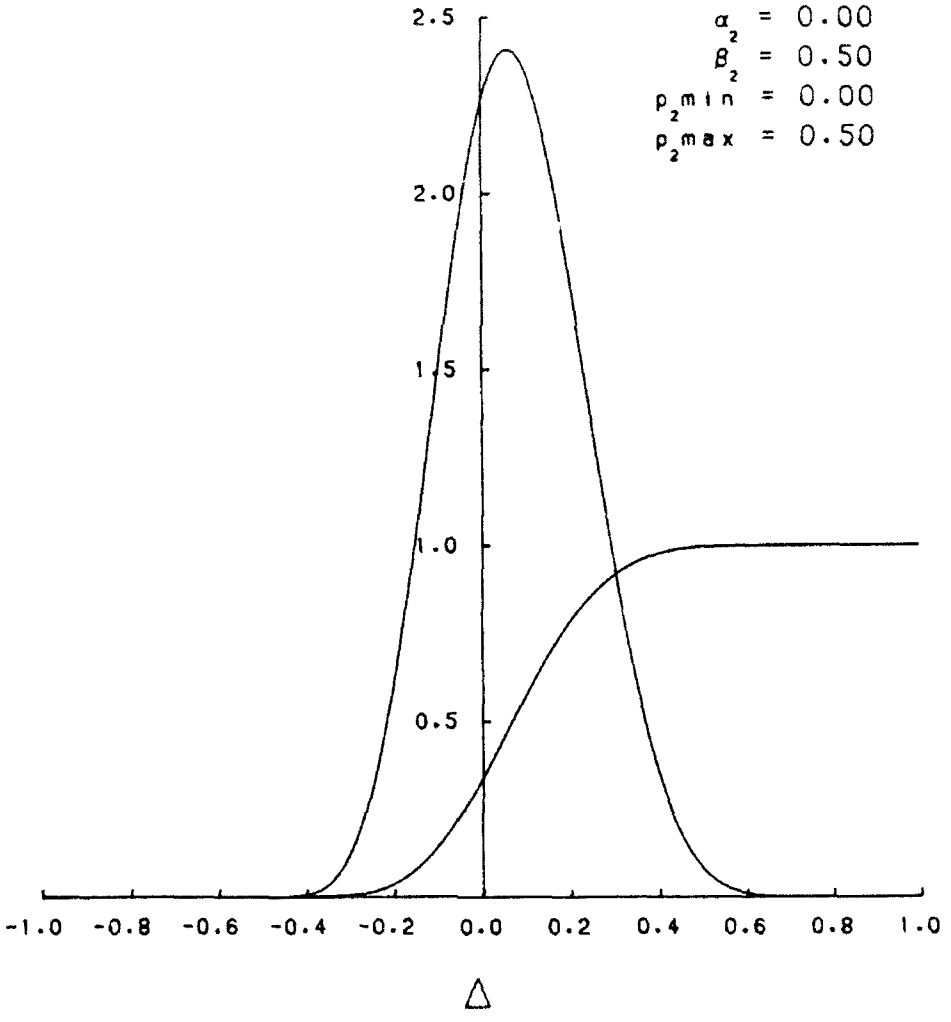
DENSITY AND DISTRIBUTION
UNIFORM PRIOR RISK DIFFERENCE

$i1 = 4 \quad i2 = 7 \quad n1 = 10 \quad n2 = 20$



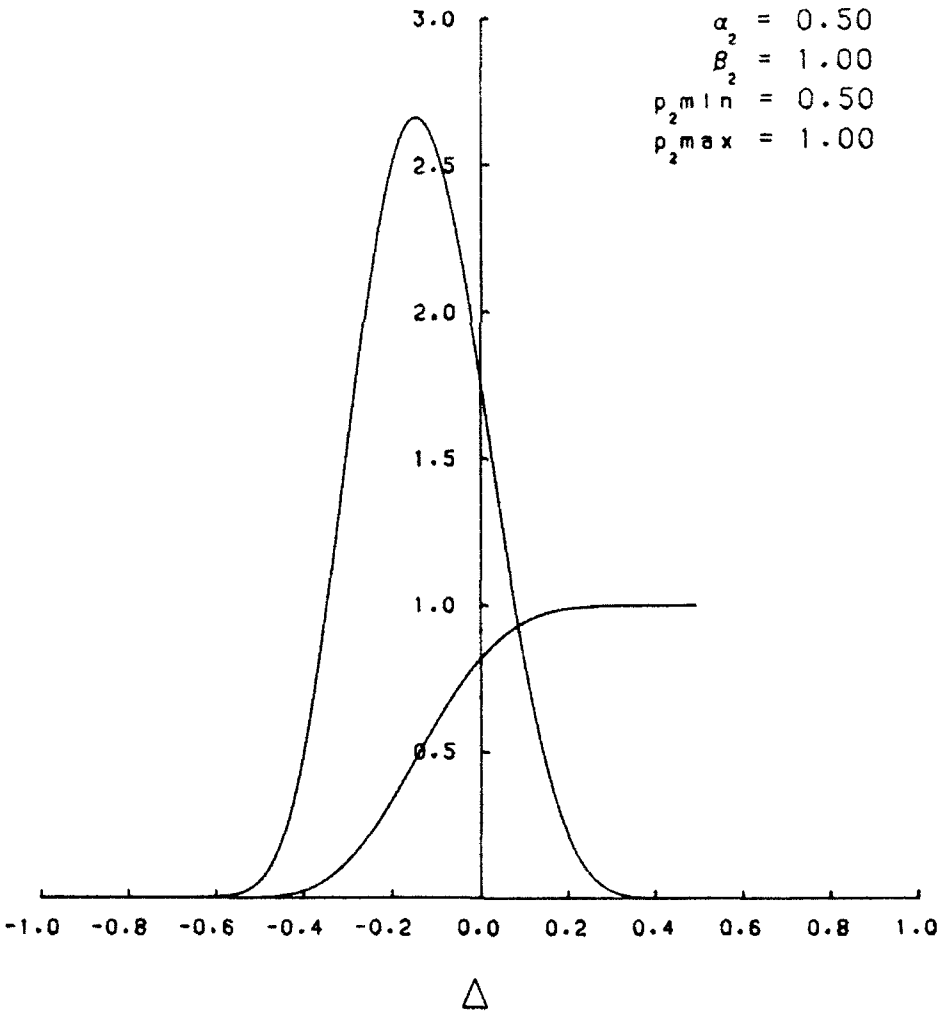
DENSITY AND DISTRIBUTION
CONSTRAINED PRIOR RISK DIFFERENCE

$i1 = 4 \quad i2 = 7 \quad n1 = 10 \quad n2 = 20$



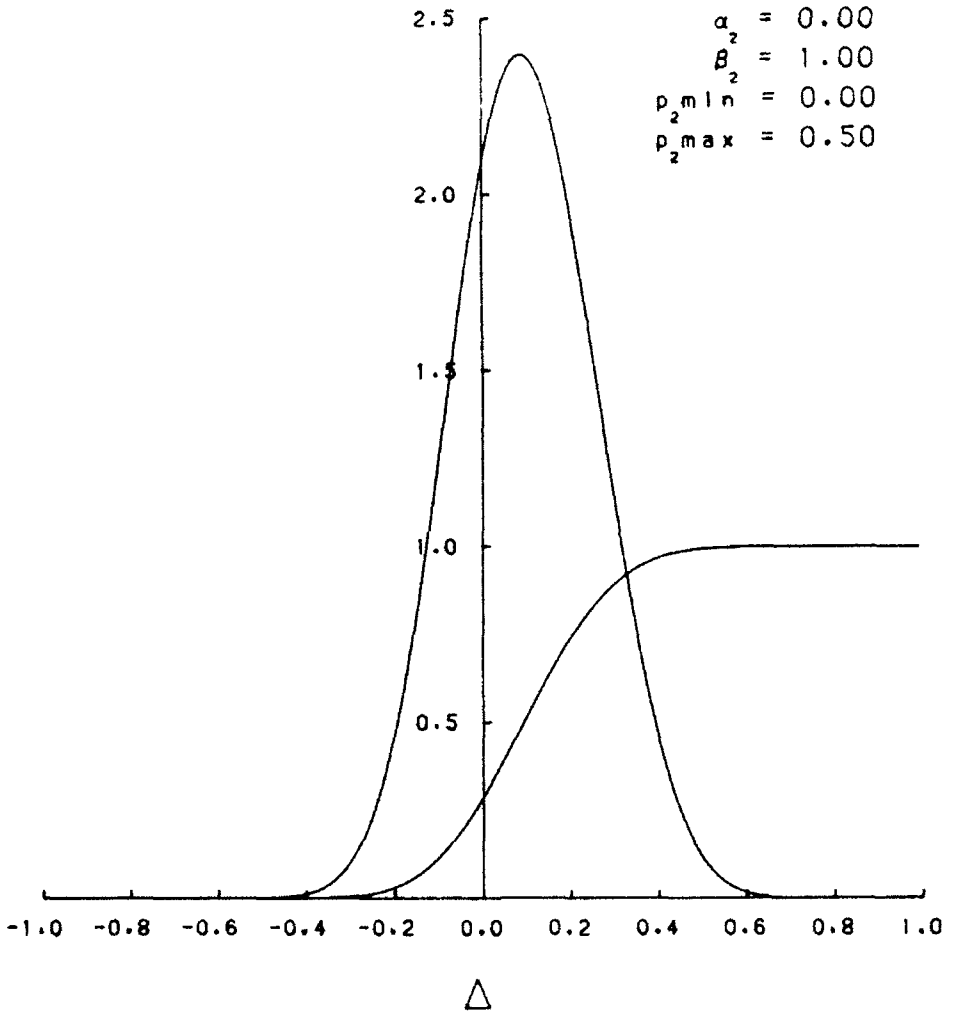
DENSITY AND DISTRIBUTION
CONSTRAINED PRIOR RISK DIFFERENCE

$i1 = 4$ $i2 = 7$ $n1 = 10$ $n2 = 20$



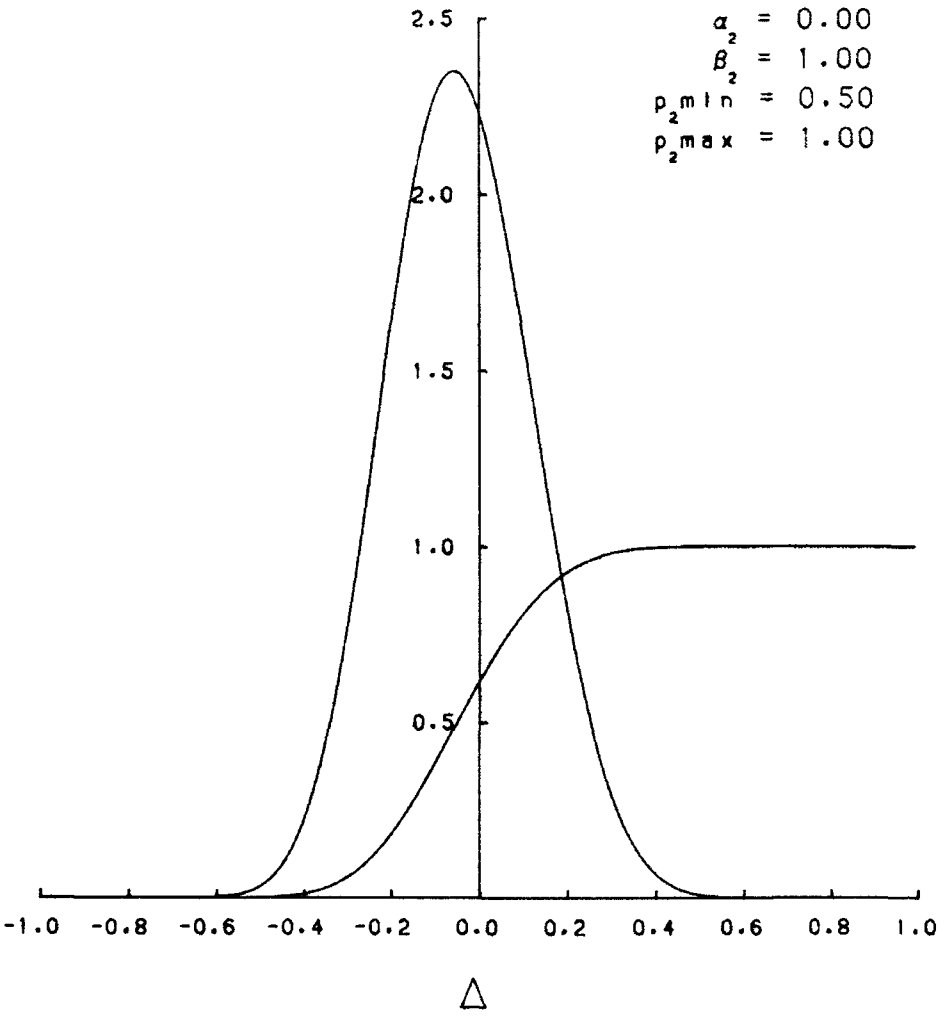
DENSITY AND DISTRIBUTION
BETA PRIOR RISK DIFFERENCE

i1 = 4 i2 = 7 n1 = 10 n2 = 20



DENSITY AND DISTRIBUTION
BETA PRIOR RISK DIFFERENCE

i1 = 4 i2 = 7 n1 = 10 n2 = 20



Conclusion

After executing my program for risk difference, I conclude that my program was successful in calculating and plotting the density and distribution. I learned the representation of a two by two table and what is meant by Uniform, Constrained, and Beta prior assumptions. Throughout this course of study I realized that the area under the density to the left of any point is equal to the height of the distribution function. This checks the validity of the two dependent functions. I was able to have the opportunity to learn how to write and understand Fortran language and how to operate the Calcomp 1044 GT pen plotter used to generate the plots. Similar programs should be written to include a Bayesian analysis of risk ratio, or relative risk, and odds ratio.

Acknowledgements

For the High School Apprentice Program summer session of 1992, I would like to thank the following people. I especially thank Mr. Tom White, who is a very wise and knowledgeable person that has taught me more than any individual book can hold. I also would like to thank Dr. Joel Michalek for being under his supervision throughout the summer session. For all of those people who read and made new suggestions concerning my report, I thank you too. Finally, and most importantly, I thank both of my parents who supported me and drove me to and from work, averaging close to 84 miles per day.

PROCEDURES USED IN THE STUDY OF THE EFFECTS OF CATHETERIZATION SURGERY ON THE STRESS LEVELS IN RATS

Stephanie A. Rodriguez

Final Report for:
Summer Research Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
Boiling Air Force Base, Washington, D.C.

August 1992

PROCEDURES USED IN THE STUDY OF THE EFFECTS OF CATHETERIZATION SURGERY ON THE STRESS LEVELS IN RATS

Stephanie A. Rodriguez

ABSTRACT

The effects of catheterization surgery on the stress levels in lab rats is being conducted using the carotid artery and tail vein. The animals body weight and food intake were recorded before and after catheterization, to determine whether there was any disturbance to the animals habits.

The records showed an extreme drop in both food intake and body weight after carotid catheterization. Blood samples are taken from the rats which have undergone catheterization and used for lactate and glucose assays. The glucose assay showed low glucose levels while the lactate assay showed no significant changes in the lactate levels. The samples were also processed by High Pressure Liquid Chromatograpy (HPLC) to detect the catecholamines, epinephrine and norepinephrine. Due to insufficient time the results from the HPLC are unable to be recorded at this time.

PROCEDURES USED IN THE STUDY OF THE EFFECTS OF CATHETERIZATION SURGERY ON THE STRESS LEVELS IN RATS

Stephanie A. Rodriguez

INTRODUCTION

The effects of the catherization on the stress levels is being done to establish the catecholamine baseline levels used in the study of Gravitaitional Loss of Consciousness (GLOC). Two types of catheterization surgeries, which allow blood to be collected and stress levels to be recorded, were performed. The animals body weight and food intake were also recorded before and after the surgery to determine whether there was any disturbance with the animals habits. Glucose and Lactate assays are conducted to determine the amount of glucose and lactate, respectively, in the blood. The samples are also processed through High Pressure Liquid Chromotography (HPLC), to measure catecholamines. The catecholamines looked for are epinephrine and norepinephrine.

METHODOLOGY

Surgical procedures.

The tail vein and carotid artery where used in the catheterization surgeries. The amount of stress each created was observed and recorded. To determine whether either surgery disrupted any of the animals regular habits the animals body weight and food intake were observed. The animals body weight and food intake were recorded before catheterization and for a five day period after the surgery.

Blood collection procedures.

When collecting blood samples small eppendorf tubes were prepared with 0.5ml of Perchloric Acid with Metabisulfite. Then 0.5ml of blood is added and the solution is vortexed

immediately. The mixture turns brown and the tubes are placed in the centrifuge for ten minutes at 10,000 rpm. The supernatent is then collected from the tubes and DHBA is added to it hey are then placed in the -80°C freezer (3). The samples are used for lactate and glucose assays or on the HPLC.

HPLC procedures.

HPLC is used to measure the catecholamines norepinephrine and epinephrine. A mobile phase circulates through the hypersil column as an eluter to the chemicals being processed through HPLC. The mobile phase contains Citric Acid Monohydrate, Sodium Acetate, EDTA (disodium salt), Octanesulfonic Acid, water and methanol. There are six steps used to prepare the samples to be processed on in the HPLC. First, prepare a column by adding 1ml of Buffer 1(0.5M tris HCL, pH8.6. Dissolve 78.8 g/in 800ml of water, adjust pH with IN HCL and make up to 1000ml with water) and 10mg of alumina. Then add 0.1ml of the sample invert the mixture and place it horizontally on the mechanical shaker for ten minutes. Next, using the vaccu eluter wash the columns with three column volumes of buffer 2 (0.005M tris-HCL pH 8.6). Fourth, add 0.2ml of buffer 3 (0.1N HCL) and shake vertically on the mechanical shaker for ten minutes. Fifth, applying light pressure with a syringe plunger elute into a small eppendorf tubes. Finally, centrifuge for two minutes at 10,000 rpm, pipette the solution into limited volume inserts, place the inserts into the vial and the vial into the HPLC (3,4). The HPLC is controlled by a computer which graphs peaks showing the amount of catecholamines in the sample. It then prints out the graph, the volume inserted, the retention times, and the area of the peaks.

Glucose assay.

The glucose assays are conducted to see if the animals are eating properly after the surgery. This is determined by the amount of glucose in the sample. A glucose standard is prepared; 0.05ml of glucose is added to 4.95ml of water in a tube it is then vortexed. Next, a buffer is prepared containing 20ml of glucose buffer, 5mg of glucose oxidase, .8mg of peroxidase. Then, a dianisidine solution is prepared by adding 5mg of dianisidine to 1ml of water and vortexed.

This is added to the buffer just before the buffer is added to the samples. The tubes are prepared with the volume of each tube being 1.1ml. The sample and the water must equal 0.1ml; then0.5ml of the buffer is added and .5ml of sulfuric acid. After the tubes are prepared with the sample and water the buffer is added and the mixture incubates for 45 minutes. Then the sulfuric acid id added and the samples are processed on the spectrophotometer and the optical density (O.D) for each sample is recorded. Finally, the µmole/ml glucose blood is calculated.

Lactate assay.

The lactate assays determine how much lactate is in the blood. The amount of lactate in the blood shows whether or not the animal was straining at the time of extraction. Before processing the samples on the spectrophotometer, cuvettes must be prepared. Each cuvette must have 0.5ml of glycin buffer, 0.05ml of supernatent, 1.4ml of water and 0.04ml of NAD^+. Each sample is processed and the O.D. is recorded. Then, 0.01ml of lactic dehydrogenase is added, the samples are processed, the O.D. is recorded every 10 minutes for 30 minutes. The initial O.D. is subtracted from the final O.D. and the delta O.D. is the result. The delta O.D. is used in calculating µmole/ml lactate blood (2).

RESULTS

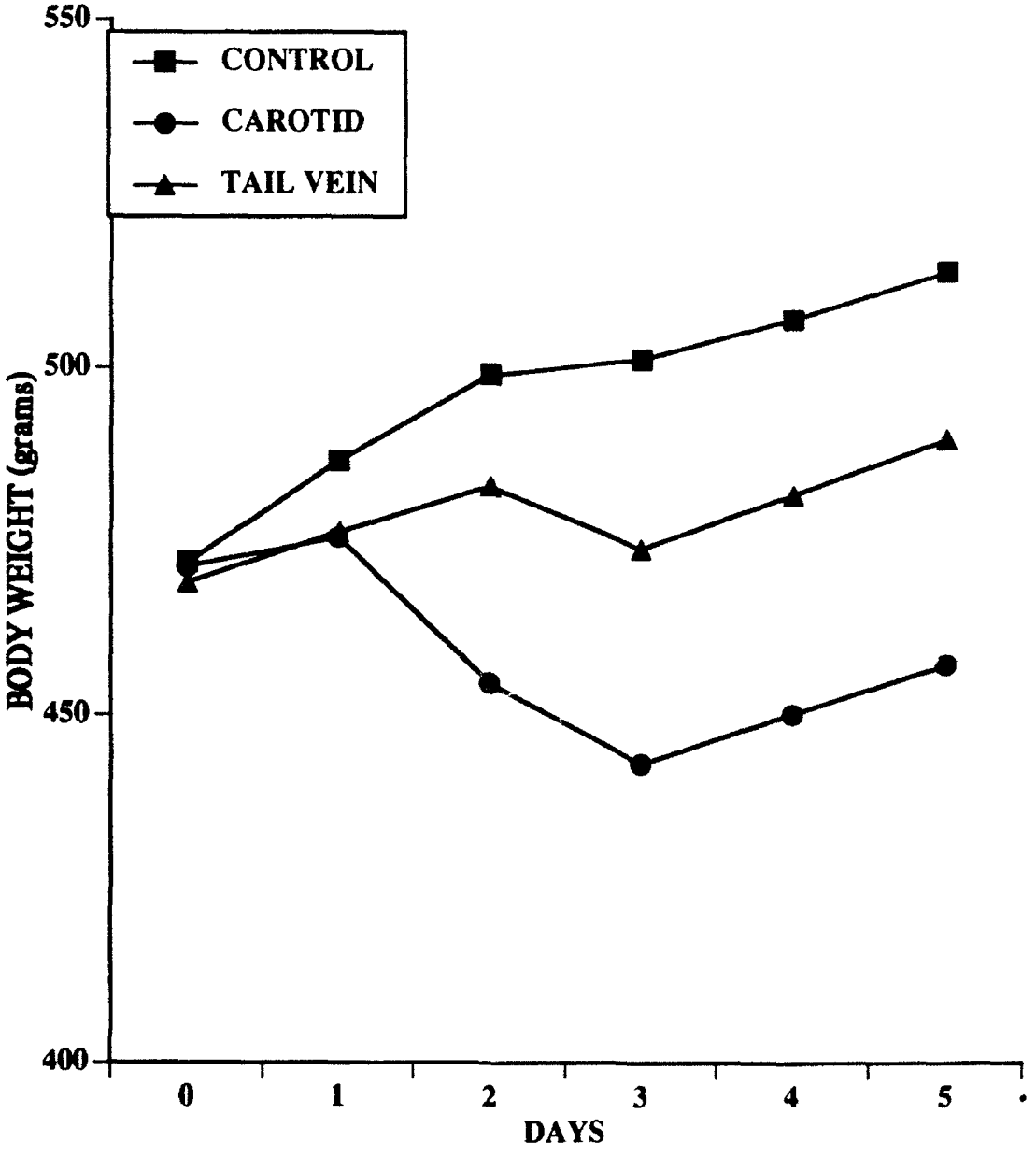
Surgical.

The results of the body weight and food intake observation are shown in graphs G-1 and G-2. The carotid catheterization caused a sharp decline in food intake. A slight decrease in body weight after the carotid catheterization was recorded. The tail vein catheterization caused a slight decline in both body weight and food intake. The control shows the proper habits of a rat without surgery.

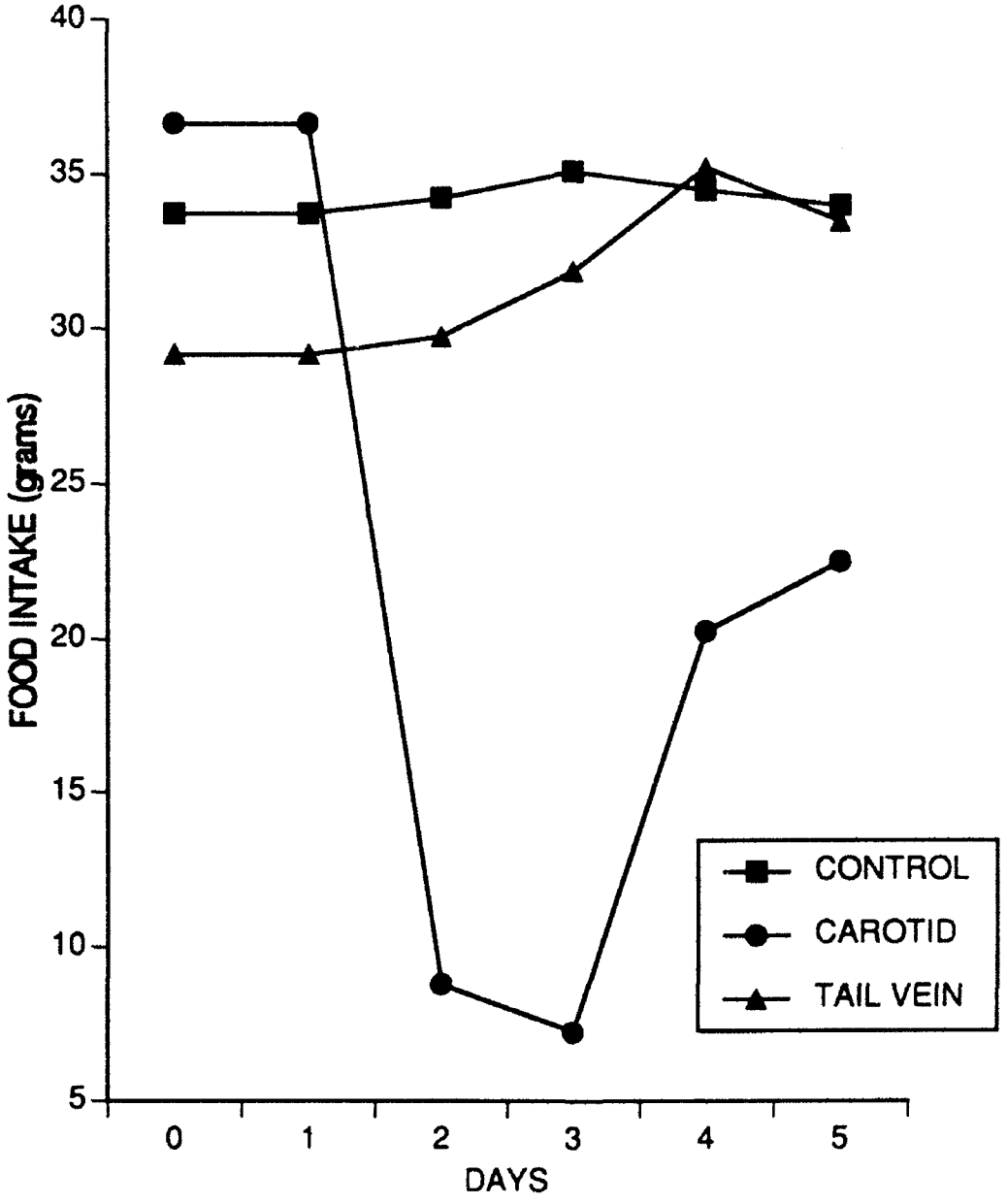
HPLC

Graph G-3 is a chromatogram showing the peaks of a standard mix. The standard mix contains epinephrine, norepinephrine, and DHBA. The graph shows the retention time, volume inserted, and the area of each peak. Each peak is labeled with its proper name.

G-1 EFFECTS OF CATHETERIZATION ON BODY WEIGHTS



G-2 EFFECTS OF CATHETERIZATION OF FOOD INTAKE



G-3

[illegible]

Printed on [illegible]

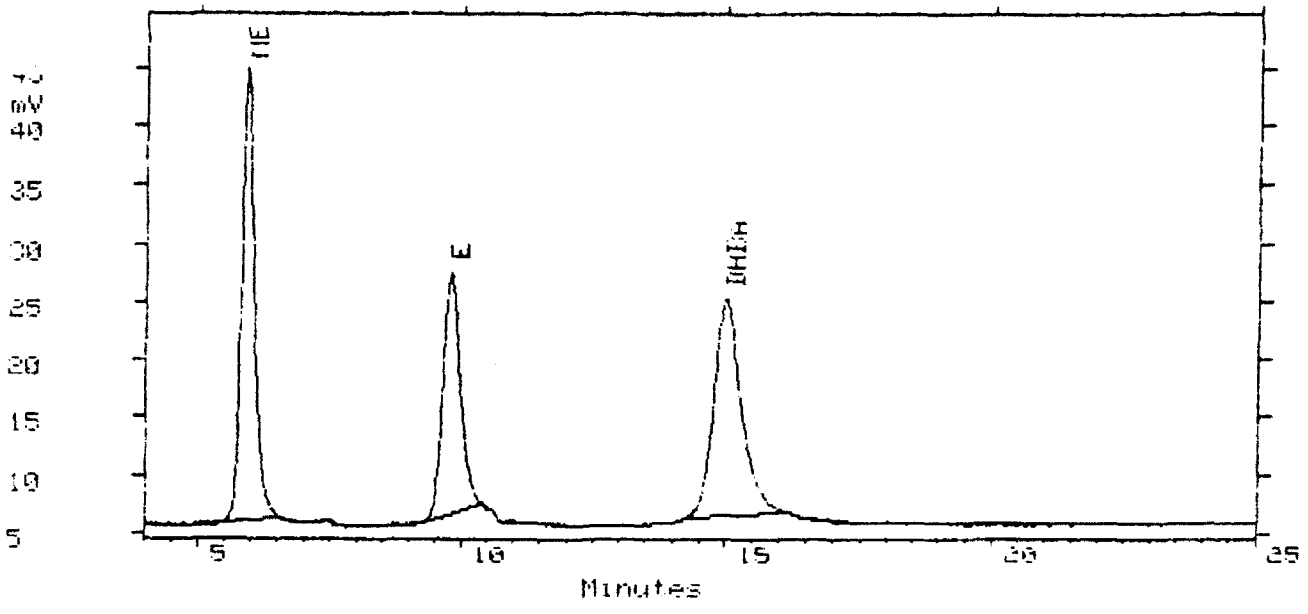
Acquisition method	ecd	Processing method	ecd
Date		System number	
Channel	1	Vial	
Injection	1	Total injections	
Run time	25.00 min	Sample type	[illegible]
Injection volume	[illegible] uL	Mode	[illegible]
Acquisition version	5.3	Quantitation version	[illegible]

DSA

CITRATE BUFFER : EDTA+ DSA +6% methanol, pH 4.35

10 pmol standard mix

Chromatogram of 082092



Peak Name	Ret time	Area	Height	Type	Amount	Intercept	Slope	Response
NE	5.88	661220	38783	BB	9.653	0.000e+00	6.850e+04	6.61220e+05
E	9.76	497656	20919	BB	8.731	0.000e+00	5.700e+04	4.97656e+05
DHBA	14.99	680714	18762	BB	9.137	0.000e+00	7.450e+04	6.80714e+05

Amounts have been computed with manually entered responses

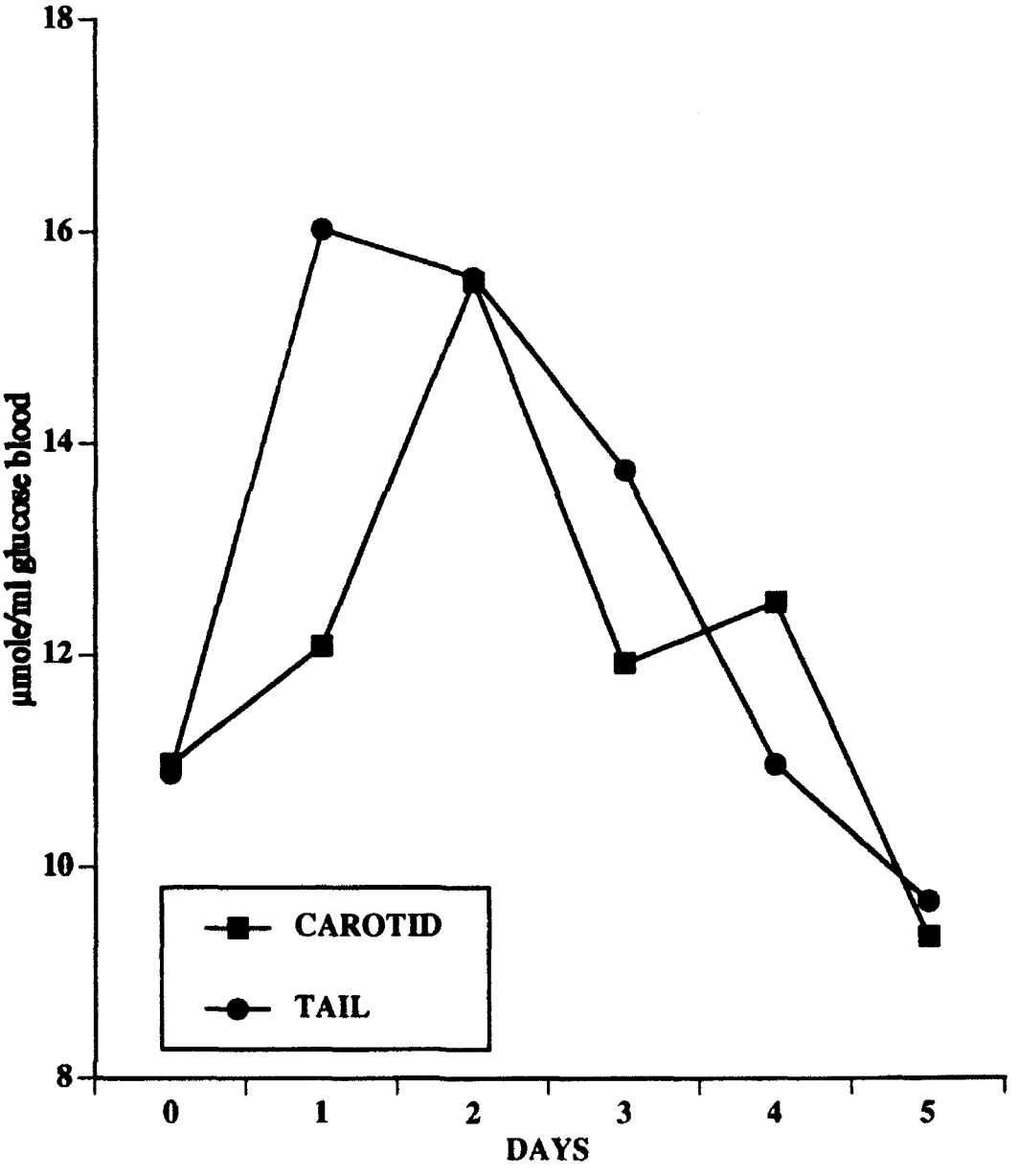
Glucose and Lactate assays.

Figure G-4 shows the amount of glucose in the blood at the time of extraction. The glucose levels rise in both samples for two days after the surgery then return to the normal level. The lactate levels in the blood are shown in figure G-5. The lactate levels had no significant change in either sample.

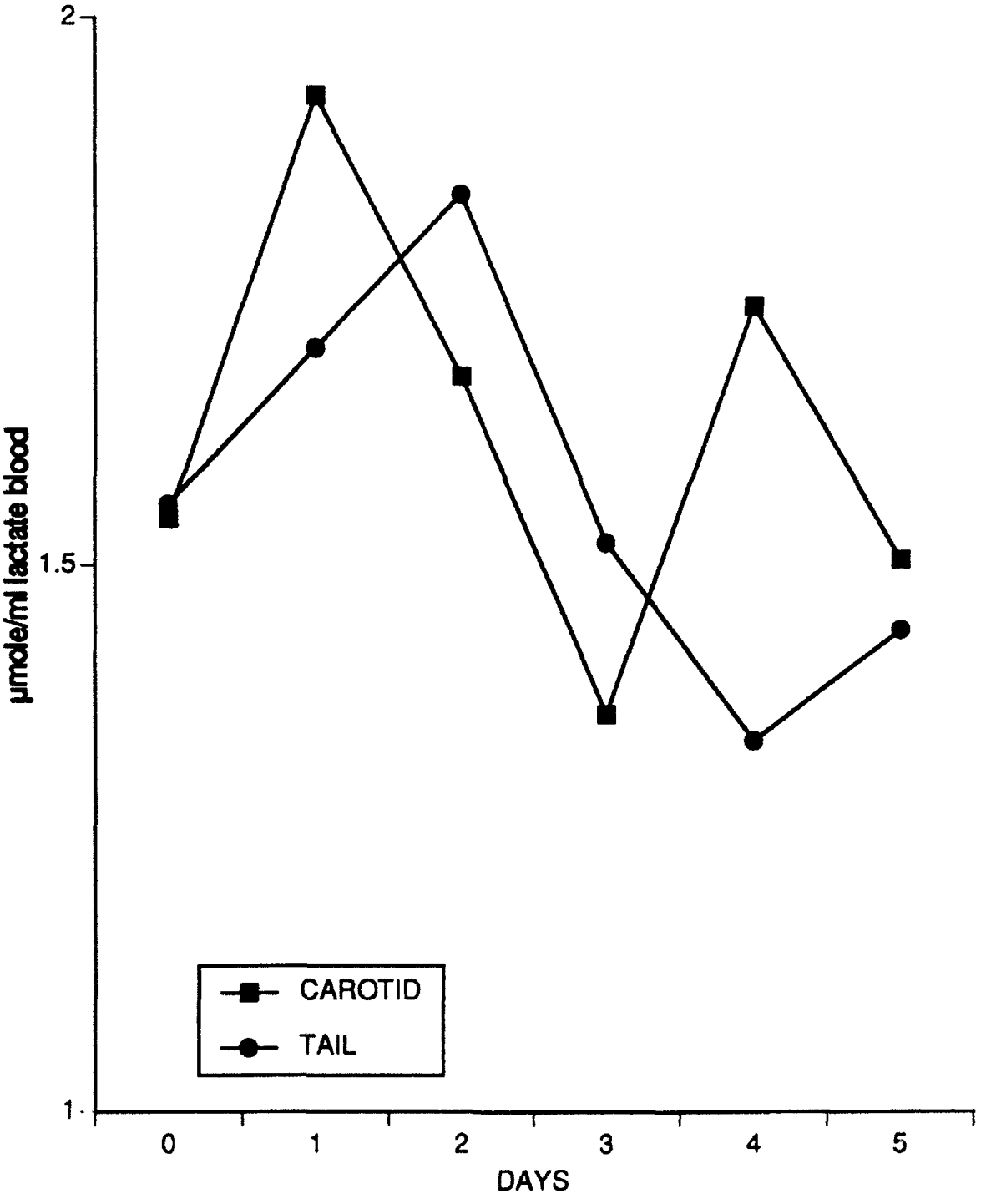
CONCLUSION

The data shows that the tail vein catheterization may be less stressful to the rat than the carotid. The glucose levels in both rats rose for the first two days after surgery then returned to the normal level. The lactate levels did not change significantly. The rat which underwent the carotid catheterization had a sharp decrease in food intake. Due to insufficient time the results of the catecholamine measurements were not completed.

G-4 BLOOD GLUCOSE LEVELS AFTER SURGERY



G-5 BLOOD LACTATE LEVELS AFTER SURGERY



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THE EFFECTS OF MELATONIN ON DIURNAL FATIGUE LEVELS

Carol A. Salinas

Final Report for:
Summer Research Program
Armstrong Laboratory
Brooks Air Force Base

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, Washington, D.C.

August 1992

THE EFFECTS OF MELATONIN ON DIURNAL FATIGUE LEVELS

Carol A. Salinas

Abstract

In this study, the ability of melatonin to induce measurable levels of both physical and mental fatigue was examined. Also, the question of whether salivary melatonin levels are reliable measures of overall melatonin levels was addressed. A final goal of this study was to prove that smalle. doses of melatonin (i.e. 10 mg) produce fatigue just as effectively as the larger, pharmacologic doses (i.e. 240 mg) now being tested. Three subjects each received two cumulative oral doses of placebo or melatonin during the course of a 9 1/2 hour session. Their oral temperatures, salivary melatonin levels, and serum melatonin levels were recorded during this period. Each subject was also required to subjectively rate his/her own fatigue level in an overall sense (physically and mentally). Finally, the subjects had to record their activity levels during the testing session. The resulting data indicated that melatonin does indeed produce measurable levels of both physical and mental fatigue, even during the daytime. In addition, a close parallel between serum and salivary melatonin levels was discovered in the course of the study, establishing salivary melatonin levels as a reliable, less intrusive index of systemic melatonin.

THE EFFECTS OF MELATONIN ON DIURNAL FATIGUE LEVELS

Carol A. Salinas

INTRODUCTION

In our society today, fatigue is a ubiquitous adversary. Shift work, extended duty days, and the need to cross multiple time zones are common in both industry and the military. For example, in the military, duty days of C-141 crew members were extended as long as 24 hours during the frantic efforts of Desert Shield and Desert Storm (Neville, 1992). These types of working schedules are associated with health problems, such as gastrointestinal disorders (e.g. peptic ulcers) and cardiovascular disease. Furthermore, shift workers tend to have higher incidences of sick leave and visits to work site clinics. These working conditions also seem to produce sleep disturbances, as is shown by the fact that shift workers often report that they have trouble sleeping (Congress of the United States, 1991). In addition, anyone who has ever experienced jet-lag knows that crossing multiple time zones can also lead to sleep disturbances. Another problematic result of extended duty days, shift work, and crossing multiple time zones is a general decrement in performance levels for the worker/traveler. Working in these types of situations can even lead to safety threats. Fatigue in human engineers has been linked to such tragic calamities as the Three-Mile Island nuclear accident, which occurred in 1979, and the Chernobyl nuclear tragedy (Neville, 1992).

Due to the deleterious effects of fatigue, there is a strong desire to control our own sleep cycles. We, as a society in general, have made numerous attempts to alter how tired or alert we are at a given time. Several substances have been utilized in the hopes of inducing natural sleep. Alcohol is quite

effective for inducing artificial sleep, but after a few hours it produces insomnia (usually in the later sleep stages); it also suppresses normal sleep EEG patterns and it does not allow REM to take place. Sedatives, such as benzodiazapine, have also been used to induce sleep, but they, too, do not allow a person to experience normal sleep EEG patterns, primarily because they depress slow wave sleep. On the other hand, other chemical substances, such as caffeine, xanthines, and amphetamines, have been employed in the hopes of producing a natural state of alertness in people. However, all have side effects (i.e. loss of appetite, hyperactivity, headaches, hypertension, and a tendency to become habit-forming) and are not completely effective (personal communique, Dr. Jon French, Brooks AFB, 1992). Therefore, at present, it seems that our own sleep cycles still control us, and not vice versa.

However, there is new hope of being in control of our sleep cycles using a substance that may be less harmful and more effective. Nevertheless, this substance would have to be one that is already a part of our physiological structure, one that our own bodies manufacture naturally. It would also have to be largely responsible for controlling our sleep cycles. There is such a substance, and its name is melatonin. Melatonin is a hormonal compound which, in mammals, is produced in the pineal gland. It has been linked with both the sleep cycle and fatigue levels. Since humankind does not enjoy being captive to its sleep cycle, the hormone melatonin holds great promise because it can allow us to control that cycle. The ingestion of this hormone may allow us to induce natural, restful sleep, as opposed to the unnatural, altered sleep induced by artificial agents (i.e. sleeping pills and available drugs). There would be numerous worthwhile aeromedical applications if these ideas were to be established as valid ones. As far as inducing alertness, previous research has

proven that cognitive performance during nocturnal periods can be enhanced by brightly-lit surroundings (Badia et al., 1990; Campbell et al., 1990; French et al., 1990). It has been theorized that this phenomenon is due to the suppression of the normal nighttime increase in serum melatonin levels by wide spectrum light (Lieberman et al., 1985), as depicted in Figure 1 below (wherein the dark circles represent the normal nocturnal rise and the white triangles represent the bright-light suppressed levels).

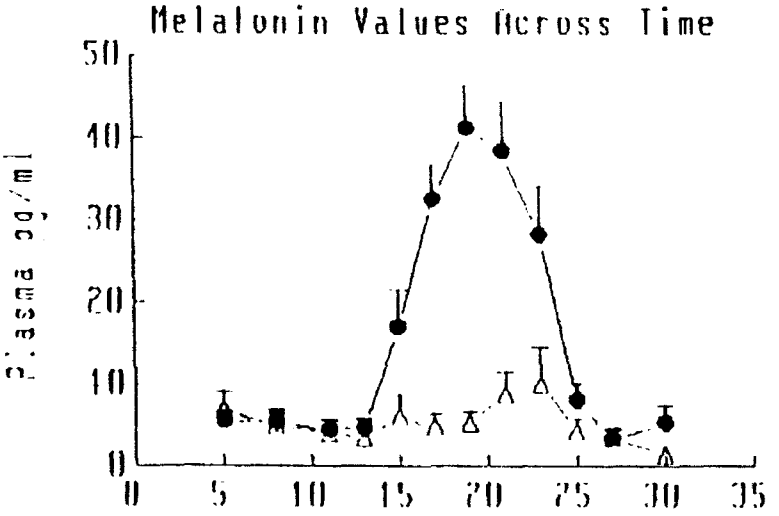

Figure 1 Black circles = normal nighttime surge of melatonin between 2000 hours and 0600 hours; white triangles = results of bright-light suppression.

Thus, there were two main reasons for undertaking this study. First, the ability of melatonin to produce measurable levels of both physical and mental

fatigue needed to be examined. Physical fatigue was evidenced by oral temperature curves, since a decrease in temperature indicates an increase in fatigue. Mental fatigue levels were evidenced by subjective fatigue ratings given by the subjects. These measures were expected to correspond with measures of melatonin levels. Second, the question of whether salivary melatonin levels are reliable measures of overall melatonin levels had to be addressed. The reason for this is that salivary melatonin measurement is less intrusive and more convenient than the current method of measuring melatonin by blood serum levels. Therefore, if salivary melatonin measurement is found to be reliable, future studies could measure systemic melatonin levels by taking salivary samples instead of serum samples.

There are many possible avenues for investigation concerning the use of melatonin to induce fatigue. There are countless potential uses for it in both the military and in industry. It is speculated that utilizing melatonin to bring about sleep/wake phase shifting would help minimize jet-lag. In the military, it could also be used to help us prepare for night missions. In industry, it could greatly alleviate the strain of shift working by helping workers cope with new shifts and/or night work, and maybe even in helping them physiologically adjust to these stressful working schedules, which at present is practically impossible.

METHODOLOGY

Subjects

The group of volunteers was relatively small and consisted of two males and one female, all civilian, Air Force employed non-smokers, and all aged under 40 years. They received no monetary reimbursement, they could not take any drugs

for 24 hours before testing began, and they had to have a normal nighttime rest period before the test weekend itself. Finally, they were required to stay out of the sun as much as they possibly could during the 7 days prior to the study itself. All of the above safeguards were inserted into the experimental protocol to guarantee that subjects were experiencing normal circadian rhythmical patterns before the test session.

Procedure

The session lasted 9 1/2 hours and took place on a Saturday. On this day, the 3 volunteers arrived at the lab center at 0800 hours so that a number 20F teflon intracath (which had a heparin lock to prevent blood clotting) could be inserted into either a forearm or antecubital vein. When the test session officially started at 0830 hours, blood samples would be drawn every 2 hours (with the last sample being taken at 1730 on the same day), so these catheters were used to prevent as much discomfort as possible for the subjects. At 0900 hours and at 1245 hours all three subjects were given medication without knowing whether it was placebo or melatonin. At 0830 the first blood sample was drawn, and this was utilized as a baseline to guarantee that melatonin levels were stabilized. From then on, blood samples (each being a 10 cc sample) were taken every 2 hours, salivary samples (also, each being a 10 cc sample) were taken every 2 hours, and oral temperatures were taken three times every hour. In addition, every hour each volunteer subjectively rated his/her own quantitative fatigue level (using a standardized scale of 1 to 7, with a rating of 1 being extremely energetic and a rating of 7 being completely exhausted) and recorded his/her activity levels. (The activity levels were not very high, since none of the subjects were allowed to do any extremely strenuous activities.) The last

samples/measurements of the test session were taken/recorded at 1730 hours, since that was when the session ended.

In this study, either two increasing amounts of melatonin (10 mg and 90 mg mixed up in methylcellulose for a total dosage of 100 mg) or equivalent amounts of methylcellulose by itself (as a placebo) were used. If it were a 70 kg subject being used, then these doses would be 0.14 and 1.29 mg/kg. In order to insure the incorporation of melatonin, and to control for any other dietary processes which might influence individual outcome, fruit juice and water were the only available sources of nutrition, and they were offered once every hour.

RESULTS

Figure 2 demonstrates the strong relationship between serum and salivary melatonin levels, evidencing the reliability of salivary melatonin as an indicator of overall melatonin levels. Furthermore, both serum and salivary levels of melatonin increased greatly after ingestion of 10 mg of melatonin as well as after ingestion of 100 mg of melatonin, supporting the effectiveness of the lower (10 mg) dose. These increases in salivary and serum melatonin levels are associated with decreases in oral temperature (see Figure 2) and increases in subjective fatigue (see Figure 3), demonstrating the effectiveness of melatonin as a sleep and fatigue inducing agent. Interestingly, both of these relationships, as revealed in Figures 2 and 3, are more pronounced following ingestion of the 10 mg melatonin dose than after ingestion of the 100 mg melatonin dose. Since it is known that melatonin easily diffuses across tissue compartments, the rapid peak effect and onset rate portrayed below were expected.

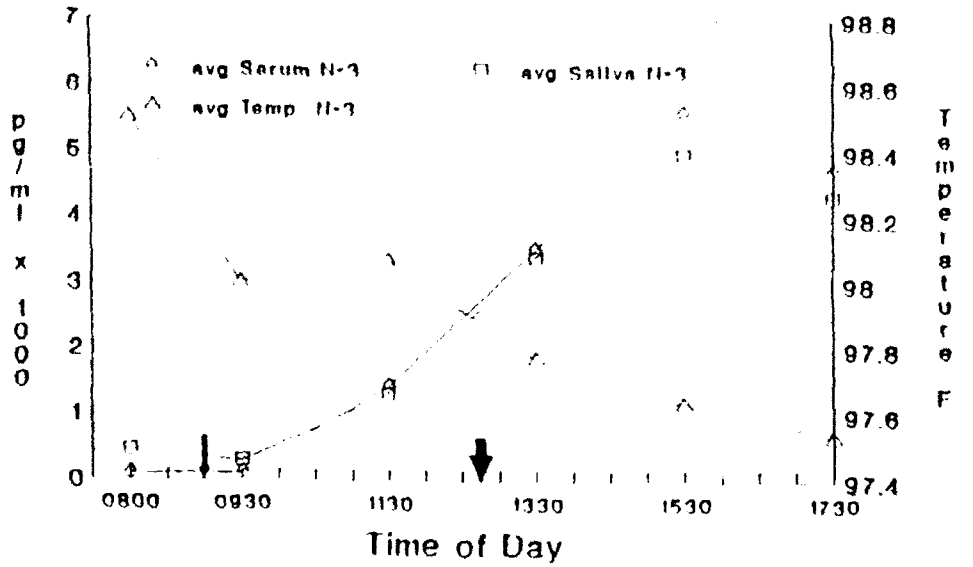

Figure 2 As serum and salivary melatonin levels increase, temperature levels decrease.

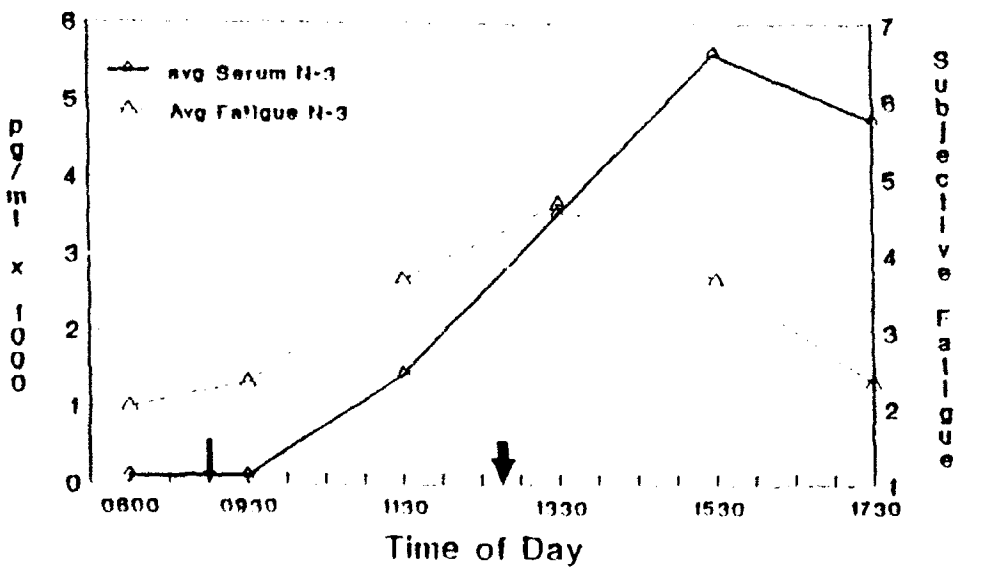

Figure 3 Thin arrow = 10 mg dose; thick arrow = 100 mg dose; low subjective fatigue ratings = low fatigue levels and high subjective fatigue ratings = high fatigue levels; high serum levels = large amounts of melatonin and low serum levels = low amounts of melatonin.

CONCLUSIONS

In this study, it was established that the dosage of melatonin required in order to yield normal serum melatonin levels is just as competent in producing fatigue as are the relatively larger (240 mg) doses which have been studied up until now. (In other words, it was shown that 10 mg of melatonin was just as effective in producing fatigue as 100 mg of melatonin was.) Serum and salivary melatonin levels reliably and linearly relate, and this parallel clearly establishes salivary melatonin as an adequate index of systemic melatonin. Also illustrated were the connections between melatonin levels, the commencement and term of fatigue, and oral temperature. Fatigue levels and temperature levels are inversely related; this study demonstrated that both of these dynamics are influenced (in a dose dependent fashion) by melatonin administration.

This study was very productive. Through its findings, we now have, in salivary melatonin measurement, a less intrusive way o measure systemic melatonin levels. We are also now aware of the fact that 10 mg doses of melatonin can be used in place of larger, possibly more harmful doses. In addition, we have also found, in melatonin, a more effective, safer way to control our own sleep cycles.

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COMPARISON OF HUMAN TEMPERATURE TRANSDUCERS

PAUL SALINAS

Final Report for :
Summer Research Program
Armstrong Laboratory
Brooks Air Force Base

Sponsored by :
Air Force Office of Scientific Research
Bolling Air Force Base, Washington DC

August 1992

COMPARISON OF HUMAN TEMPERATURE TRANSDUCERS

PAUL SALINAS

Abstract

The stability of human temperature measurements by 3 transducers were compared over time. An oral and 2 tympanic temperature devices were compared over a 3 day period in 5 male and 5 female volunteers. Subjects were coached in proper recording techniques and an investigator conducted the tympanic measurement. Three temperature readings were taken in succession from each device every recording trial to evaluate the reliability of each device. No statistics were obtained but visual assessment of the average recordings from all subjects indicated that all devices seemed to measure consistantly during a trial. One of the tympanic devices (First Temp) was an expensive clinical model but measured approximately the same as the inexpensive oral model designed for home use (within 0.05 degrees). All devices showed similar direction and magnitude of temperature change. A circadian pattern to the data was evident in that morning temperature was lower than afternoon temperature. Also, the average human temperature did not seem to be 98.6 as has often been cited. Average human temperature was compiled from the oral thermometer (hourly, from 0600 - 2300 hrs), and was 98.3 degrees. This study concludes that temperature may be a useful indicator of circadian patterns and that the oral device used may be regarded as sensitive a measure of temperature as some clinical models.

Introduction

Body temperature is an important indicator of the human physiological condition. Doctors have used temperature for years to determine illnesses such as fever in many patients. Scientists use temperature assessment to monitor circadian rhythms (24 hour cycles) and metabolic levels. Currently, body temperature is one of the most important gauges of illness for the home. As well, body temperature can be used to help plan for a pregnancy. Given that temperature is so important, a way to obtain a consistent (reliable) and an accurate (valid) reading is needed. A wide variety of commercial thermometers are available for measuring temperature non-invasively. For example, there is much interest in tympanic measurement of temperature in the clinical and home settings. Oral temperature has been available for many years but today's microchip technology provides these thermometers with accuracy to the tenths of a degree and digital memories. This paper examines the effectiveness of common ways of taking body temperature.

There are many means to assess temperature but this study focused on two in particular, the oral and the tympanic routes of assessment. These two routes were chosen because they are most often used in science, research, and even in the home. Oral temperature is the most common and familiar. Since the ear is located near the hypothalamus, the body's temperature control area,

it may be an excellent place to determine core or body temperature, not just ear temperature. Accordingly, two tympanic thermometers were chosen for comparison.

Tympanic thermometers have attracted a lot of interest because the ear canal is less affected by the environment like a breathing, eating or speaking mouth would be. The eardrum and surrounding tissue give off heat in the form of infrared waves. These devices initiate the millisecond measurement of tympanic infrared waves and then calculate body temperature. Most models convert this energy reading into an oral or rectal equivalent and display it on the digital screen in a matter of seconds. The objective of the investigation was to determine the reliability and validity as well as comparability of the three temperature transducers. Reliability would be assessed by comparing at least three readings in immediate succession every time temperature was obtained. Validity would be suggested by the comparability of the measurements.

Methods

The oral thermometer chosen for the experiment was the Becton Dickinson digital thermometer (#2860, Becton Dickinson & Co., Ruthford, NJ). This thermometer is inexpensive ($10 retail), easy to use and has digital decimal readings. As well, it makes an audible signal when a stable temperature is obtained.
Second, a home use thermometer called Thermoscan (Thermoscan #421049A, Thermoscan Inc, San Diego, CA), which retails for about

$120, was purchased commercially. Finally, a clinical grade thermometer, First Temp Genius, model 3000A, was graciously loaned to the investigators by Bionic Systems, Inc Dallas, TX
This thermometer costs around $400.

Five male and five female civilian volunteers where chosen from the high school and college summer student population at Brooks Air Force Base. Subjects were each given a packet which contained an oral thermometer, a data-activity log, a diet history sheet, a sleep survey, and a symptom questionnaire. All subjects were given thorough instructions on the proper procedures of the different temperature methods. In addition, all subjects were given practice trials taking their own oral and tympanic temperatures so temperature would be consistently and correctly measured. Directions on how to fill the data-activity logs were also given. After any questions were answered, the subjects signed a voluntary consent form and began the experiment.

All subjects were required to wear actigraphs (Precision Instruments, Fort Walton, FL) during the 48 hour experimentation period. The actigraphs were worn because actigraph output could be used to monitor sleep and activity periods. The 48 hour experimental period began at 1200 hours and ended at 1200 hours 48 hours later. During the entire 48 hour period, subjects took their own oral temperature three times every hour on the hour starting at noon and recorded these temperatures on the data-activity logs.

When the subjects went to sleep, no temperatures were taken. Tympanic temperature was taken three times each, on every odd hours at 1300 hours and 1500 hours the first day and beginning at 0900 and ending at 1500 hours on the second day. On the third final day temperature also started at 0900 but ended at 1100 hours making a total of eight temperature times throughout the 48 hour period. Tympanic temperature was taken in one pre-designated ear. Temperature taken with the Thermoscan was taken in the right ear and temperature taken with the First Temp Genius was taken in the left ear. Subjects were also warned not to eat or drink anything 15 minutes prior to taking their temperature. Also, subjects entered their subjective fatigue and workload information onto their activity sheets whenever they took their temperature. Quality of sleep ratings also were entered for the prior nights sleep. Diet history sheets were completed when subjects ate or drank any kind of food during the experiment.

Results

All data were visually analyzed on graphs. More sophisticated statistical analyses were beyond the scope of this effort but will be computed in a larger study comparing rectal (core) body temperature with these devices. The first question in this analysis concerns the reliability of the three temperature transducers. This was evaluated by graphing the 3 individual readings from each device whenever temperature was taken. Figure 1 shows the oral thermometer readings during the 48 hour period. Temperature was

averaged across all ten subjects and plotted by for each time point taken. In all the figures, time of day refers to the time temperature was taken on the hour. For all the figures, values 1, 2, and 3 refer to the three successive temperature readings the subjects took their temperature. Oral temperature shown in Figure 1 was taken more frequently than for the tympanic temperature because the subjects could take these thermometers home with them.

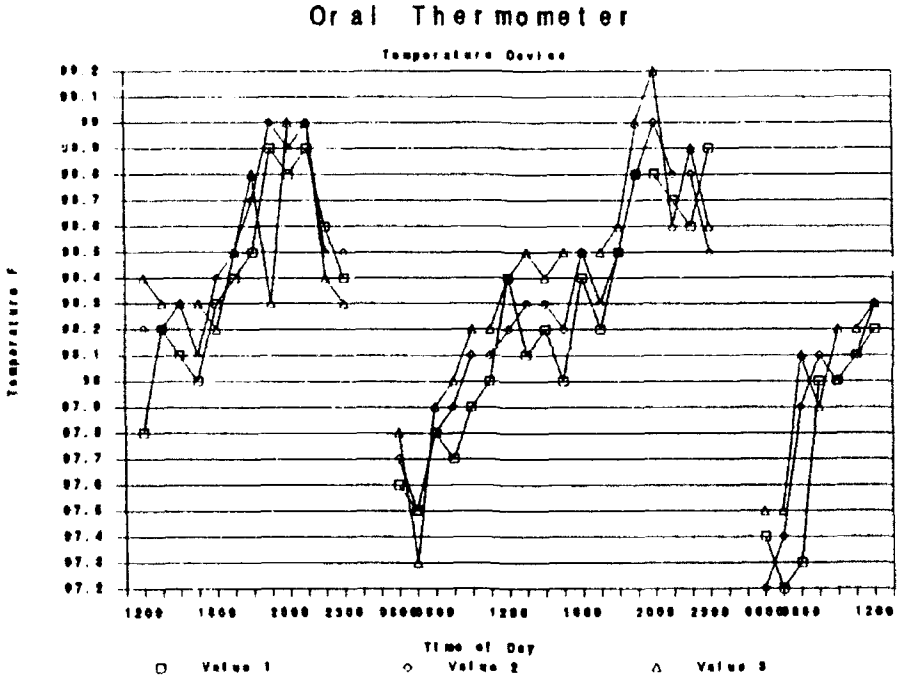

Figure 1 Oral temperature recorded three times at each time point comparing the reliability of the device.

Figure 2 shows the tympanic temperature readings of the ThermoScan averaged across subjects on Day 1 through Day 3. Temperature did vary throughout the time of day however the values for day 1, 2, and 3 were not as consistent throughout the 48 hour

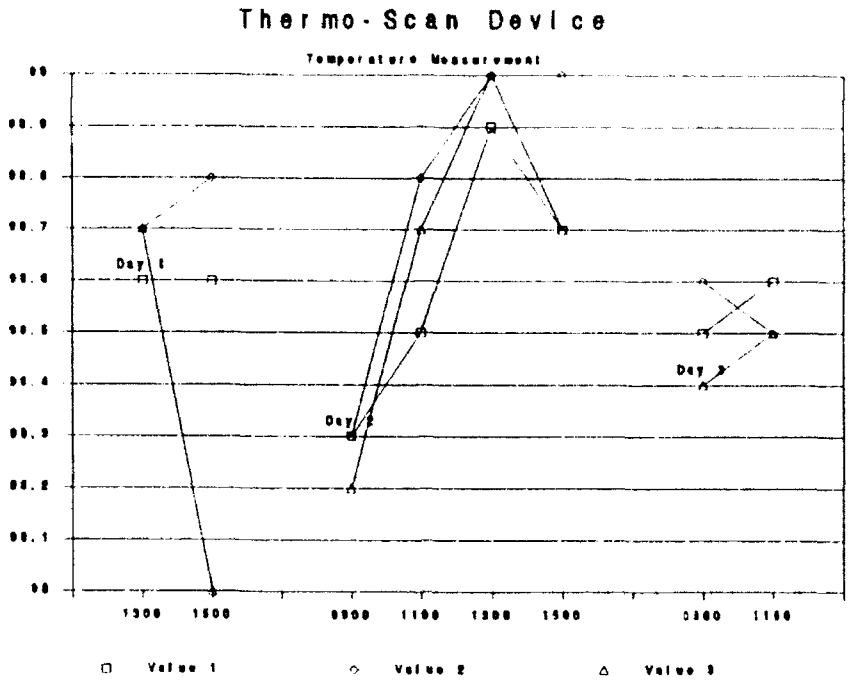

Figure 2. ThermoScan recordings of temperature across hours within each of the 3 days.

period as were the oral thermometer data in Figure 1.

Figure 3 shows the tympanic temperature readings of the First Temp Genius 3000A. Temperature was averaged and plotted across Time of Day as before. Temperature taken only reached a high of 98.4 degrees, as shown in Figure 3, however temperature taken reached a high of 99 degrees. Although values for days 1 through 3 were variable, they seemed to be less so than for the device in Figure 2. Temperature taken first was usually warmer than the temperature taken last.

Finally, the devices seemed to be measuring temperature about

the same. Figure 4 shows that the oral thermometer and the First Temp Genius device are very comparable, differing by only 0.05 degrees on occasion. The Thermoscan device seemed to read consistently higher than the other 2 devices but the direction and magnitude of temperature change is the same as the other 2 devices. The higher temperature of the Thermoscan device may be due to the setting on the device being put on Rectal equivalent rather than Oral equivalent.

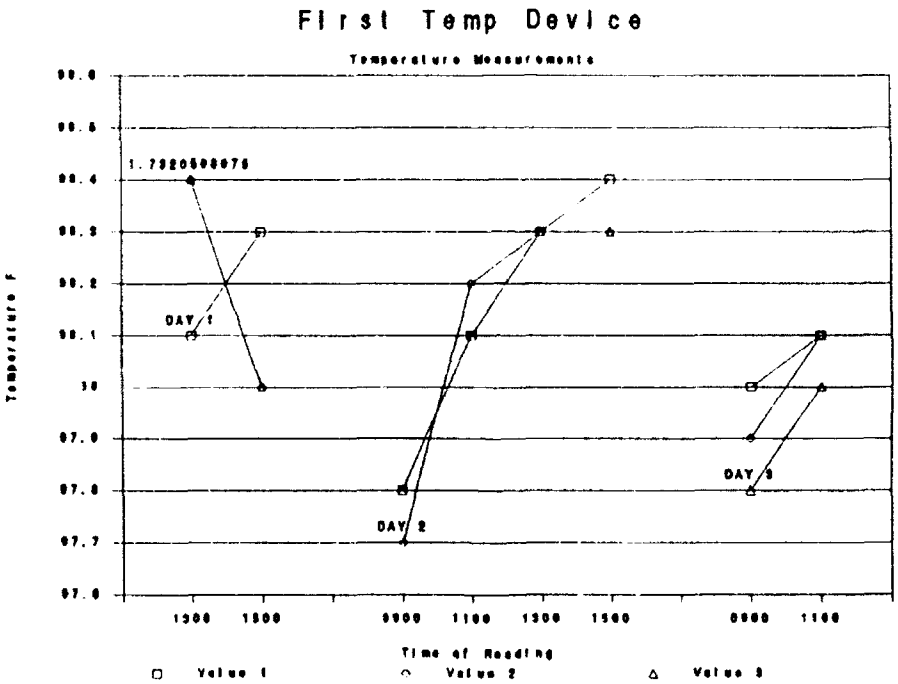

Figure 3. First Temp Device temperature measures across hours within each of the 3 days.

Actigraph data and activity log data were not included in the analysis. However, these data were reviewed to insure the subjects daily habits were comparable. They will be the focus of a later study comparing core temperature with the measures described here.

Using oral temperature values for Day 2, the average temperature between 0600 and 2300 was 98.3. However, this did not include the early morning temperatures when body temperature is lowest.

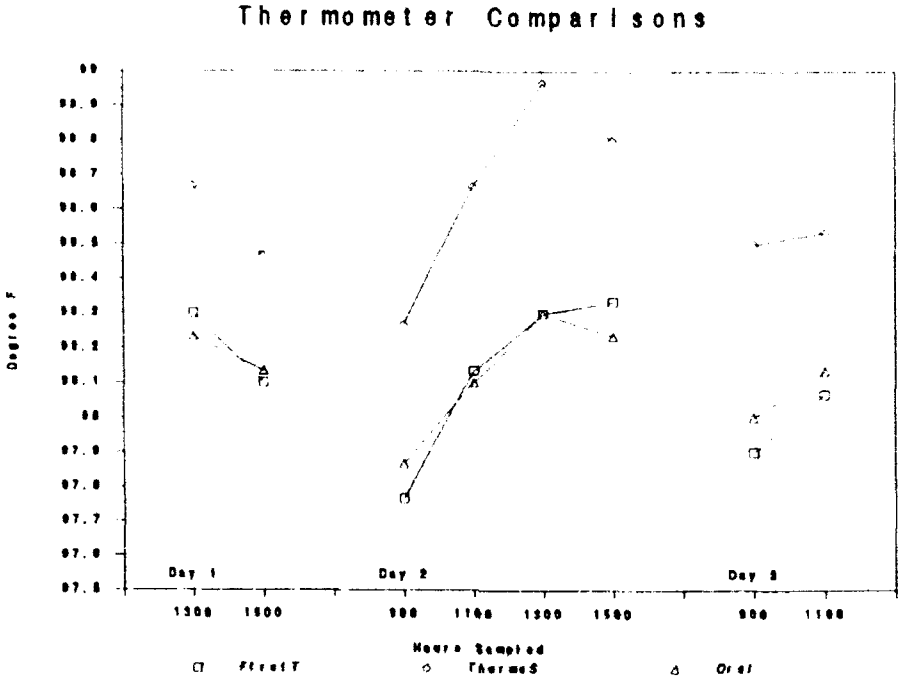

Figure 4. Comparison of oral and 2 tympanic temperature devices where the measurements were obtained at the same time of day.

Discussion

The most important questions in the analyses concerned the reliability of the three temperature transducers. Figure 1 showed an example of the reliability of the oral thermometer between trials (values) and across days. The first of the three oral thermometer readings is usually cooler than the second or third time. This is probably because prior to the first temperature reading the subject may have been talking or otherwise had their mouths open. This could have let cooler air enter the mouth. On the second trial,

temperature increased a degree on the average. On the third and final trial temperature was increased once again about a degree. The steady increase in temperature across trials may have resulted because the mouth was kept closed for minutes at a time due to the prior readings. It usually took one to two minutes to take a reading on the oral thermometer which totaled about 5 minutes that the mouth was closed. This suggests that when taking oral temperature, a better reading would result from multiple readings. This would probably help alleviate false readings and allow a more precise body temperature.

The ThermoScan device however did not show as distinct a trend for the first reading to be cooler than the subsequent readings, as did the oral thermometer. This might be because temperature using the tympanic device was not taken every hour as the oral thermometer was. Since the ThermoScan is an over the counter (ie not clinical grade) tympanic thermometer it also might have been less reliable than other devices.

The First Temp Genius seemed to have a trend in the reverse direction of the other 2 devices; that is temperature taken on trial 1 was usually warmer and temperature taken on trial 3 was usually cooler. These results may be due to the fact that every time temperature was taken in the ear and the device was removed the warm air inside the ear was also removed. The clinical grade First Temp device may have been more sensitive to this change than

the ThermoScan.

This analysis only focused on a 48 period, but was done to give a better understanding of the reliability of temperature devices between tympanic and oral devices. Considering accuarcy and expense, the temperature device of choice would seem to be the oral thermometer. All devices seemed to show a consistent circadian rhythm throughout the 48 hour period, that is, temperature seemed to reach its low point at about 0700 hours and peak at about 2000 hours. It is interesting to this investigator that the average human temperature was not 98.6 degrees as has been cited in medical literature for more than a century. Using the oral measurements, because there were more of them and they occurred more frequently, the average human temperature was found to be 98.3 although this did not include the early morning times when temperature is lowest.

This report concludes that the temperature devices studied are consistant within trials, when multiple readings are compared and across days. The First Temp Genius tympanic device and the oral device were comparable in their reading of temperature. A distinct circadian temperature curve was partially generated by the data and suggest that oral temperature may be a convenient means of recording this form of biological rhythmicity.

A STUDY ON POSTURAL IMBALANCE IN HUMANS AS RELATED TO OCULAR DOMINANCE

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Final Report for:
Summer Research Program
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A STUDY ON POSTURAL IMBALANCE IN HUMANS AS RELATED TO OCULAR DOMINANCE

Abstract

Vestibular asymmetry in humans causes an imbalance in posture. Consequently, a person's head tilts in the direction they perceive to be "straight". The direction depends on ocular dominance. A person can be right or left eyed just as they can be right or left handed. Someone who is right eyed will have a head tilt towards their left, and someone who is left eyed will have a rightward head tilt.

Pictures were taken of seventy subjects and the tilt angle of their head in comparison to straight lines on a chart behind them was measured. Not all people conformed to the general theory. In fact the theory was disproved. The percentage of subjects that followed the basic idea was only slightly higher than the percentage of those who did not conform.

A STUDY ON POSTURAL IMBALANCE IN HUMANS AS RELATED TO OCULAR DOMINANCE

INTRODUCTION

Lateralization is no longer a question as far as the average human being is concerned. If someone is right or left handed, than that is the way they are. If someone is said to be left brained it is generally accepted that the person is oriented towards math and science. I someone is right brained they are generally considered to be artistic and creative. However, what many people do not realize is that humans can also be right or left eyed.

In the ear the vestibular organ controls balance. The vestibule, which makes up the bony labyrinth along with the cochlea and semicircular canals, contains two otolith organs called the utricle and the saccule. They provide information to the brain on position and linear motion of the head. Inside the utricle are the otolithic membranes which displace endolymph and change position relative to their maculae (thickened walls of the utricle and saccule) when exposed to a change in gravitoinertial force. This shift results in the bending of the cilia of the macular hair cells by the otolithic membrane which is right above the cilia. The bending of the hairs triggers neural activity. In essence, they tell the brain that the head is tilted.

The vestibular organs in humans are asymmetrical, so a person's head always has a slight tilt when it is compared to a straight line. What appears and feels straight and level to the individual is actually horizontally angled. Though the person may not realize it their head is crooked. Some people have extremely slight imbalances in their vestibular organs, so their head is closer to being straight, nevertheless, there is a tilt.

Ocular dominance also has an impact on the direction of the tilt of the head. What a person sees, and how they perceive it, often determines how they are going to look at it, and they often look at it with their head cocked to one side. Eye dominance contributes to the direction. The dominant eye is usually the eye with better vision. Often, it is the one that a person prefers to look through a microscope or telescope with. Depending on which eye is dominant the head is going to tilt in the opposite direction. If the right eye is dominant the head will tilt to the left, and if the left eye is dominant the head tilts to the right.

Methodology

Seventy subjects were tested. They were chosen on the basis of a few restrictions. They could not be over 50 years of age (the oldest was 50), or under 15 years (the youngest was 16). They could not have had any serious back problems or neck problems, no surgery that would affect posture, i.e. knee, leg, back, or neck surgery.

The subjects went through 16 tests, including tests for eye preference, eye dominance, and phoria tests. A minority of the test required the subjects to take their shoes off. Women were asked to remove shoulder pads, if possible.

First, if the subject had an even subject number they started the tests with their right hand, and if they had an odd number they began each test with their left hand. The first eight test were to find eye dominance. In the first test the subject was given a cone to look through the small hole at one end with one eye. The eye they chose to look with was recorded. This tested eye preference. The second test used the same cone. The subject looked through the wide end of the cone and focused with both eyes open on the number one on a poster across from them. They were instructed to close their right or left

eye depending on their subject number, and then asked if they could still see the number. Then they closed the other eye and asked the question again. When they closed their eye and could not see the number the closed eye was recorded. That eye was the dominant one. After this they were asked to turn the cone over, put it in the other hand, and look through the hole again to re-test preference. Finally they were told to turn the cone over again, look through the hole with both eyes at the one on the poster, and repeat the previous test holding the cone in the hand they had not used before. These were the first four tests.

The next four tests also checked dominance. The subject was asked to take his shoes off and stand about three feet away from a door. On the door was a large rectangular piece of paper with horizontal and vertical lines ruled on it in black. It was simply a large chart that had been adhered to the door with the aid of a level and a roll of masking tape. The subject was given a red marker and asked to align it with a vertical line with both eyes open. One of the subject's eyes was covered (the right or left depending on subject number) with an opaque piece of plastic. They were then asked if the image seemed to shift when their eye was covered. If the image shifted the eye that was covered was recorded. That was the dominant eye. The test was done using both hands. Then the subject's eye was covered again, but this time they were asked to look for a vertical shift in the image of the marker. They were told that the movement would be extremely slight and hardly noticeable at all, so they would have to concentrate on determining if there was a shift or not. This test was also done with both hands.

For the next test the subject was asked to stand against the chart facing the tripod set up in the hall. The subject was centered against the chart directly under a vertical line. Using a Polaroid Spectra instamatic camera two pictures of each subject were taken. The subjects had to stand up straight with their arms at their sides and staring down the middle of the hall. Later the

picture were copied on a Xerox copier with a 200% size increase. Then a line was drawn down the midline of the face vertically and through the face horizontally. Angle measurements were taken of the deviation between the straight lines on the chart and the lines drawn on the picture of the subject. This was done for both pictures of each subject, so a total of four measurements was taken per subject.

The last eight tests were visual phoria (an imbalance in eye position) tests. These tests resulted in raw number data which has not yet been analyzed.

Results

No formal statistical analysis has been made of yet. The study is not finished. However, glancing at and estimating the outcome of the data the study revealed that the theory did not work out as planned. There was not a significant number of subjects that conformed to the theory.

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BULK ASBESTOS TESTING PROCEDURES

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Final Report for:
High School Apprenticeship Program

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, Washington, D.C.

August 1992

BULK ASBESTOS TESTING PROCEDURES

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Abstract

The testing procedures in the Bulk Asbestos Function at Brooks Air Force Base were studied. Different materials call for different testing procedures. The standard method of testing for asbestos containing materials is polarized light microscopy. This method of testing is used for building materials including insulation, ceiling tiles, surface coatings, asbestos board, pipe coverings, etc. This method is not used for floor tiles unless fibers can be liberated from non-friable matrix. If the fibers cannot be seperated, the vinyl asbestos tile (VAT) method is used. The VAT method can also be used with mastics and roofing material. Both methods can determine the presence or the absence of six types of asbestos: chrysotile-asbestos, riebeckite-asbestos (crocidolite), anthophyllite-asbestos, tremolite-asbestos and actinolite-asbestos and also determine the quantitative estimate of the percent of asbestos.

BULK ASBESTOS TESTING PROCEDURES

John D. Silva

TESTING

The bulk samples that are sent in for analysis are first examined with a stereomicroscope for homogeneity, the presence or absence of fibrous constituents, preliminary fiber identification and an estimate of fiber content.

After the initial observation, positive identification of fibers or the confirmation of the absence of fibers is done by the analysis of subsamples with the polarized light microscope (PLM). Using plane polarized light allows the determination of the index of refraction parallel to elongation. Shape and color are observed. Orientation of the two polarizers so that their vibration directions are perpendicular (crossed polars) allows observation of the birefringence and extinction characteristics of anisotropic particles can be determined.

Final identification of the unknown is made by comparing their optical properties to those samples in our reference collection. The following are the optical properties that are used to determine whether or not a sample contains asbestos: morphology, color and pleochroism, index of refraction parallel to elongation, birefringence, extinction characteristics and sign of elongation.

PLM PREPARATION

During initial preparation. the sample is placed in a small petri dish and examined through the stereoscope. The color. the presence or absence of fibers and homogeneity are observed. Fibers suspected of being asbestos type fibers are separated with forceps and tweezers. These fibers are placed in a refractive index liquid on a microscope slide. teased apart and covered with a coverslip. If the sample is layered, which occurs quite often. a slide is prepared for each separate layer. If a sample is not readily friable, a mortar and pestle can be used to crush the material and make the fibers more accessible.

*VAT METHOD

The vinyl asbestos tile (VAT) method takes more preparation than the PLM. First the tile must be broken. It is then looked at through the stereoscope and analyzed by layer. A thin cross-section is placed on a slide along with several drops of dispersion staining liquid and heated on the hot plate with a temperature between 150 -200 F. When it has heated up, a probe is used to break up the cross-section and spread over the slide in an evenly dispersed film. A coverslip is placed over the sample and analyzed through the PLM the same way a regular sample would be done.

*This method was prepared and is employed by Jo Jean Mullen. Ms. Mullen is former Chief of Bulk Asbestos Analysis.

A STUDY ON THE EFFECT OF HYDRAULIC FLUID H-19457C ON THE REPRODUCTIVE AND ENDOCRINE SYSTEMS

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Final Report For:
Summer Research Program
Armstrong Laboratories

Sponsored by:
Air Force Office Of Scientific Research
Wright-Patterson Air Force Base, Dayton, Ohio

June and July 1992

A STUDY ON THE EFFECT OF HYDRAULIC FLUID H-19457C ON THE REPRODUCTIVE AND ENDOCRINE SYSTEMS

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ABSTRACT

The effect of hydraulic fluid H-19457C on the reproductive and adrenal systems of male and female rats was investigated. By performing daily vaginal washes, the female rats' five day estrous cycle was determined. Both male and female rats' were repeatedly oral-dosed. At scheduled periods groups of rats were placed in metabolism cages, fasted over-night, and then killed. A sperm count and motility evaluation were completed for the male rats after the sacrifice. All rats were evaluated for changes in organ weights, lesions and deformities at necropsy. Females were evaluated for changes in estrous cycles, and male rats were evaluated for sperm count, sperm shape and motility. The H-19457C hydraulic fluid was found to alter the female estrous cycle, and cause slight irritability. The males were unaffected and no other negative effects were found.

A STUDY ON THE EFFECT OF HYDRAULIC FLUID H-19457C ON THE REPRODUCTIVE AND ENDOCRINE SYSTEMS

INTRODUCTION

Triaryl phosphate based hydraulic fluids are extensively used in Navy hydraulic systems including vehicles and weapons elevators. One triaryl based hydraulic fluid that is heavily used is H-19457C, and has been given the trade name of Pyrquel 220^{R}. This fluid is primarily composed of tertiary butylphenyl phosphates, which have been known to cause delayed neurotoxic effects in man.(Doull et al., 1979) A battery of tests, including an acute neurotoxicity evaluation were performed. In the same study another triaryl phosphate based hydraulic fluid, H-19457B, was found to cause testicular degeneration and changes in the ovaries and adrenal glands. Recently a comparative toxicologic evaluation of H-19457C and Tricresylphosphate (TCP) showed abnormal effects on the structure and function in the reproductive cycle of the female Fischer 344 rats, and germ cell deterioration in male Fischer 344 rats gavaged with TCP at 400 milligrams per kilogram each day(Latendress, 1988). Endocrine effects were also noticed with rats gavaged with H-19457C every day over a sixty-three day breeding period (Latendress,1988). Because Navy personnel may come in contact with H-19457C it is imperative that it's toxicity and the exposure level at which it is safe to use H-19457C be found.

METHODOLOGY

At scheduled periods, groups of rats were killed to obtain the data for this study. To prepare for the killing, the rats are placed in metabolism cage sand fasted for twenty-four hours. Urine and feces are collected and analyzed. Terminal body weights from the rats are recorded. Carbon-dioxide or halothane is used for euthanization. Once unconscious, terminal blood samples are taken from the vena cava, and the diaphragm is snipped to be certain that the rat is dead. In addition to blood, the liver, kidneys, adrenals, ovaries, pituitary, thymus, hypothalamus, uterus, cervix, vagina, testis, and epididymus are taken and weighed. any deformities or lesions were recorded at this time, and the animals are disposed of.

These killings are taken by quality control, before any treatment is administered, three weeks into treatment, another killing is performed ten weeks into treatment, a nine week post-treatment killing is received by males only, a ten week post-treatment killing of females only, and an eighteen week post-treatment is received by only males. After a male killing a sperm count, motility, and structure and function evaluations are performed.

At the beginning of the study ninety- five male and ninety-five female rats are received. After quality control rats are examined, eight- five rats of each sex are left. The

female rats receive vaginal washes every day to determine their estrous cycle. A sample of the wash is placed on a slide and examined. If the majority of the cells on the slide are squamous cells, the rat is in estrus. Large numbers of neutrophil cells, the rat is in pro-estrus, and when white cells are more numerous, the rat is in di-estrus. By determining which type of cell is more abundant one can determine which stage of estrus the female rat is in. Vaginal washes continue for two weeks before the H-19457C is administered, while the fluid is being administered, and until all the female rats are on a normal estrous cycle.

Body weights are taken on all rats once a week. Randomization occurs before dosing starts. In randomization five rats from each sex are eliminated from the experiment. The rats that are eliminated have an abnormal estrous cycle, or low body weights. The remaining rats are broken into four groups of twenty, and are gavaged with the hydraulic fluid. The high dose group receives 1.06 milligrams per kilogram, the medium dose group receives 0.3 milligrams per kilogram, and the low dose group receives 0.1 milligrams per kilogram. The fourth group is the control group which receives sesame oil. Being orally gavage may cause distress, which may alter the rats' normal mediated metabolism. In the study the control group is gavaged causing equal distress while only receiving harmless sesame oil. Gavage treatment ends after ten weeks.

RESULTS

At the present, the only changes occurring from treatment are irregular estrous cycles in females. Male rat's sperm count and mobility have not been effected by the hydraulic fluid. However, the livers of rats that were dosed with the H-19457C hydraulic fluid were found to be ten percent larger than the control rats' livers. Some irritability was noted in higher dose groups. No lesions were found. This could indicate that the dosed rat's livers had to work harder to metabolize the hydraulic fluid.

In conclusion, H-19457C hydraulic fluid seems to have a minimal effect on the reproductive and endocrine systems, but because the study is not entirely complete, these results may differ as the study continues.

PARTITION COEFFICIENT DETERMINATION FOR THE DERMIS AND STRATUM CORNEUM

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Final Report for:
AFSOR Summer Research Program
Armstrong Laboratory
Toxicology Division

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PARTITION COEFFICIENT DETERMINATION FOR THE DERMIS AND STRATUM CORNEUM

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Abstract

The only way to find out how much chemical a person has absorbed through the skin is by knowing the rate at which the chemical is absorbed by the skin. The skin is composed of the stratum corneum (dead tissue) and the dermis (living tissue). In this study, I measured the partitioning of three organic IRP chemicals, trichloroethylene, benzene, dibromomethane, into these portions of the skin. This was accomplished by separating the dead and living tissue of the skin using a trypsin solution. The layers can then be separated and used as different samples. The skin is placed in vials which are crimped. Reference vials are also crimped. Later air is taken out of the vials and certain chemical vapors are injected into each vial. The vials are then incubated for four hours at 32 degrees Celsius. Some of the air in each vial is put into a gas chromatograph to get the area counts. With a formula it is possible to get a partition coefficient (PC). The PCs are used in the Physiologically-Based Pharmacokinetic (PBPK) model to determine the permeability constant, a measure of the rate of dermal absorption. This model mathematically keeps track of how much chemical each part of the body receives. The information the PBPK model can supply can be used to prevent chemical exposures.

PARTITION COEFFICIENT DETERMINATION FOR THE DERMIS AND STRATUM CORNEUM

Jill A. Solscheid

INTRODUCTION

People today are being exposed to more chemicals than ever before. Whether exposure occurs as a factory worker, laboratory technician, or an astronaut the rate at which the chemical is absorbed through the skin is the same. Finding the rate at which certain chemicals are absorbed through the skin is especially important to the aerospace industry since these chemicals are present in the atmosphere. By knowing the absorption rate it is possible to know how much of a chemical a person has actually taken in and, therefore, the severity of their problem. Also by knowing the absorption rate people are able to determine what kind of safety precautions need to be taken when working with those chemicals. By discovering the rate a chemical is absorbed people can prevent absorption and have better treatment if absorption should occur.

Since the stratum corneum is composed of dead tissue and the dermis is comprised of living tissue and blood vessels the skin layers must be separated in order to obtain the precise rate of absorption.

METHODOLOGY

Immediately after the skin had been collected from young male rats it was dermatomed at the .25 mm setting. This was

done to separate the stratum corneum and upper dermis from the rest of the dermis so that the following procedure could be performed. Next the skin was placed dermis side down on filter paper in a petri dish saturated with a 0.5% trypsin in phosphate buffered saline solution (see appendix A). The dishes were placed in an incubator at 37 degrees Celsius for approximately 1½ hours. Trypsin, an enzyme, caused the protein between the epidermis and dermis to break down. Therefore, the layers were able to separate. The next step was to peel and lift the stratum corneum off of the dermis. However the skin, after the layers had been pulled apart, must be placed for ten minutes on the surface of a trypsin inhibitor solution (see Appendix A) to keep the trypsin from breaking all of the protein apart. Next the skin layers were washed for thirty minutes in distilled water to make sure all of the chemicals were now washed off. As a final step for day one the skin layers must be put on screens and placed into their proper relative humidity chambers. The dermis needed to be in 95% K2SO2 in distilled water relative humidity chamber and the stratum corneum needs to be put in 75% NaCl in distilled water relative humidity chamber. The skin needed to stay for at least one night in the chambers in order for solutions to equilibrate.

The next day the stratum corneum was removed from the screens and weighed into 12.4 mL vials. The vials were then crimped shut. Next the dermis was peeled off the screens and cut into small strips. The strips were placed on the sides of the vials and weighed. For each pair of stratum corneum and

dermis was a reference vial. The reference vial was a crimped vial with just air in it. All of the samples were then placed on a vortex and incubated at 32 degrees Celsius for ten minutes. Next a needle was pushed through the septa of each vial in order to equalize the air pressure. A syringe was attached at this point and a designated amount of air was taken out of each vial. The syringe and needle were pulled out. Next an equal amount of chemical was injected into each vial. Trichloroethylene (TCE), Benzene, and dibromomethane (DBM) were used (see Appendix B). All of the samples were put in a vortex mixer at 32 degrees Celsius for four hours. Finally one mL of each sample and reference were injected into a gas chromatograph which gave area counts for each.

The results of the samples were determined by comparing the reference area counts to the sample area counts in the following equation:

$$PC = \frac{(\text{reference area cts})(\text{vial volume}) - (\text{test area cts})(\text{vial volume} - \text{sample volume})}{(\text{test area cts})(\text{sample volume})}$$

When sufficient samples were examined, a mean and standard error were determined for each chemical (Table 1). The mean was then put into the Physiologically-Based Pharmacokinetic (PBPK) model. If the PBPK model has the correct absorption rate then it can mathematically keep track of how much chemical each part of the body receives due to amount of chemical exposure and

route of exposure. Keeping track of each part of the body is possible only because the stratum corneum is used to determine the skin:media PC and the skin:blood PC for a given chemical. The skin:media PC is essential for the rate equation describing the uptake of chemical from the vehicle (media) into the skin. The skin:blood PC is necessary for the rate equation describing the uptake of chemical from skin into blood. Only when these two PCs are found can one determine when the chemical is absorbed in the body.

RESULTS

Table 1 Partition Coefficients for Stratum Corneum and Dermis for TCE, Benzene, and DBM

	stratum corneum (mean±s.e.(n))	dermis (mean±s.e.(n))
TCE	429.8±63.0(13)	5.9±.9(7)
Benzene	74.5±4.4(10)	4.9±.3(10)
DBM	290.3±16.7(15)	14.0±1.7(10)

Graphs 1, 2, and 3 show how DBM is distributed throughout the body. Graph 1 describes the concentration of DBM that goes to the liver to be metabolized and then filtered out by the kidneys. Graph 2 demonstrates the level of DBM in the blood of the arteries. Finally graph 3 measures the amount of DBM that goes into the fat, where it is stored.

CONCLUSION

Determining partition coefficients is important in order to create an accurate PBPK model. With a precise model toxicologists will be able to determine which concentrations of chemical are hazardous to your health. With this information many employees will now become more knowledgeable of their working environment. Hopefully they will use this information to minimize the health risks that they are taking.

Appendix A Solutions

The trypsin used was from Sigma, lot number 70H0439.

The trypsin inhibitor was from Sigma, lot number 40H8205.

The phosphate buffered saline is composed of

9.00 grams NaCl

6.97 grams K_2HPO_4 (0.04M)

1.36 grams KH_2PO_4 (0.01M)

dissolved into 900-950 mL distilled H_2O.

The pH must be adjusted, if necessary, to 7.4 with NaOH or HCl.

q.s. to one liter

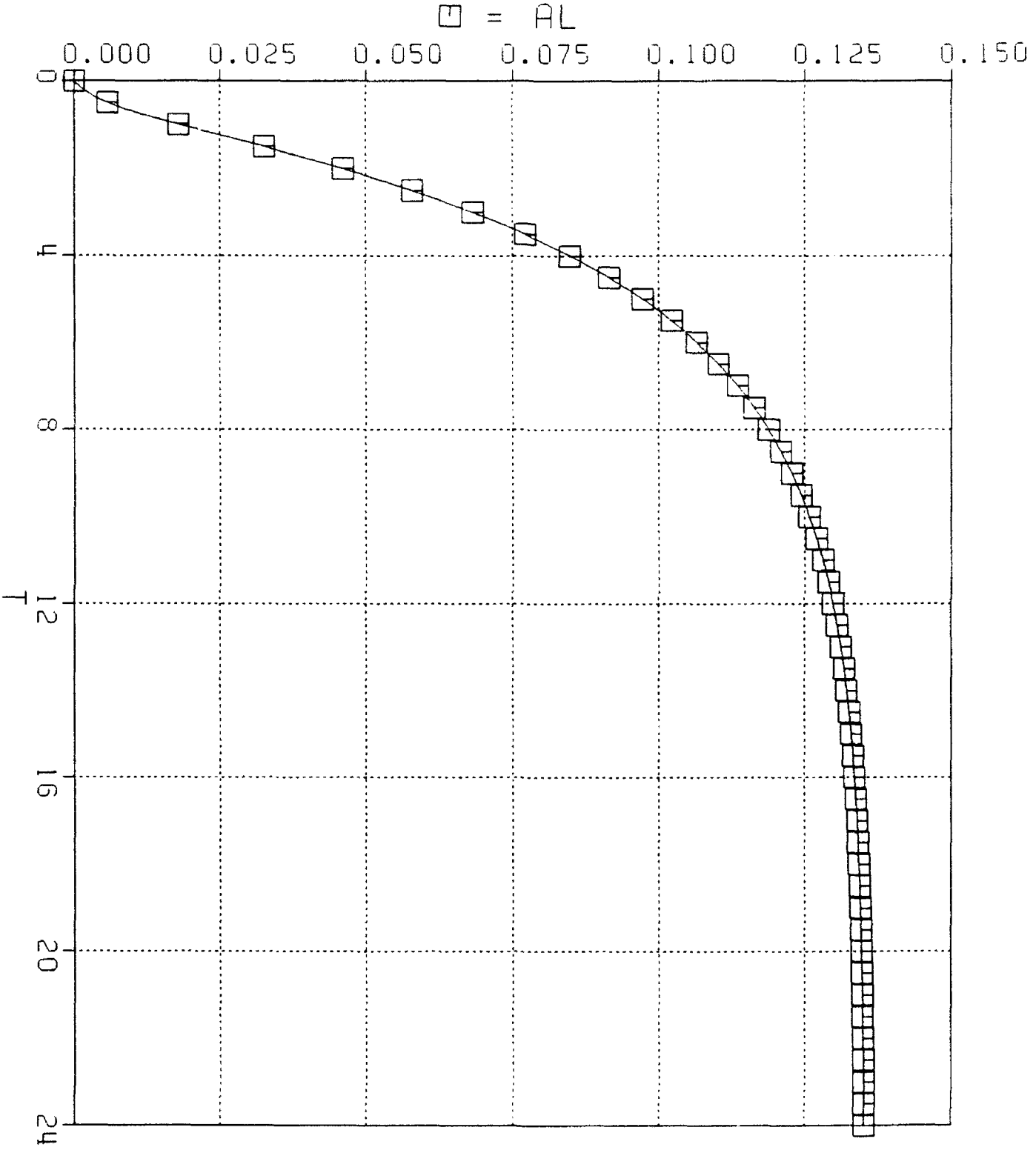
Appendix B Standard Air Bags

10,000 ppm Benzene bag was made with 183 ul of Benzene in 5 liters of air

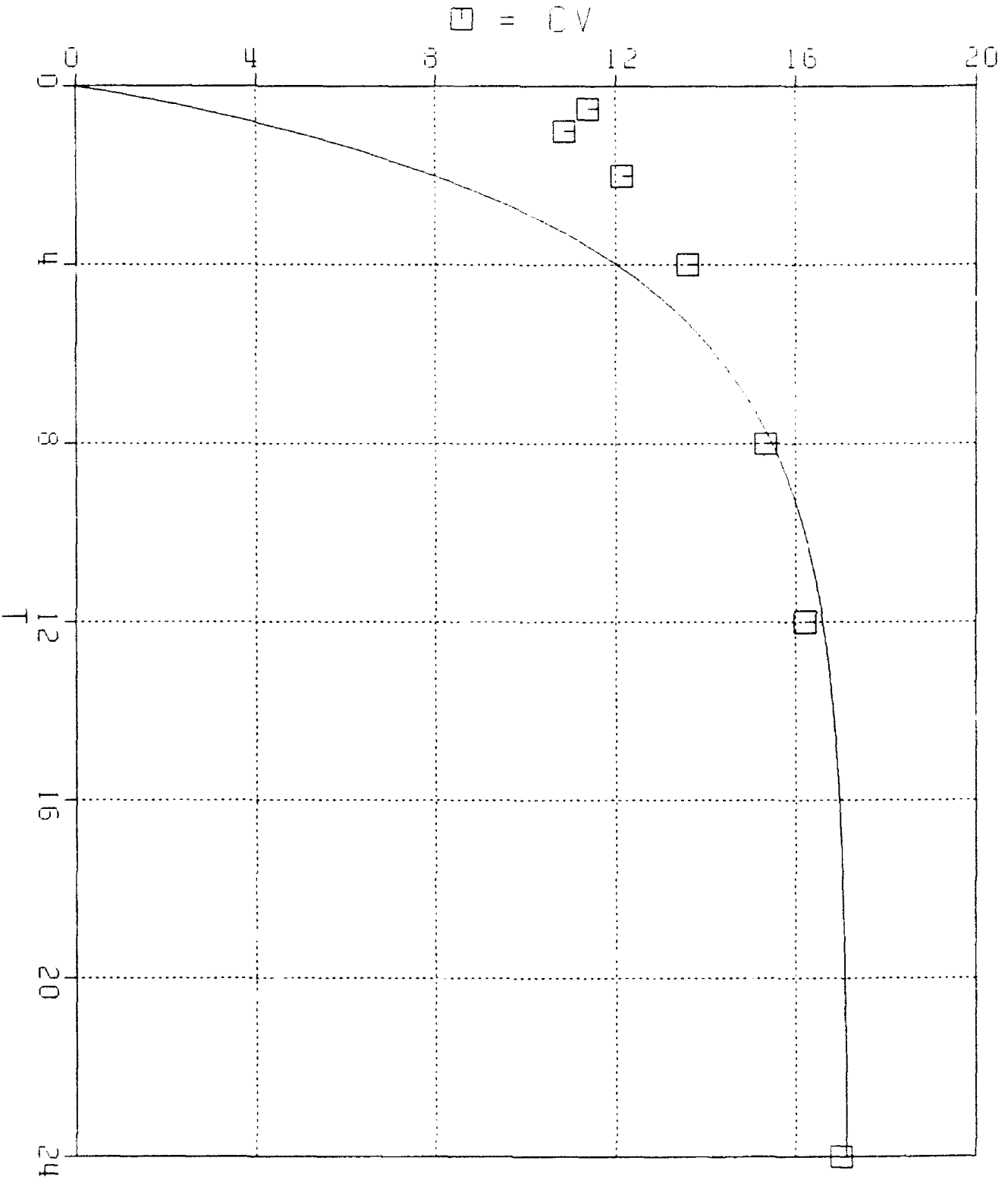
5,000 ppm TCE bag was made with 110 ul of TCE in 6 liters of air

10,000 ppm DBM bag was made with 143 ul of DBM in 5 liters of air

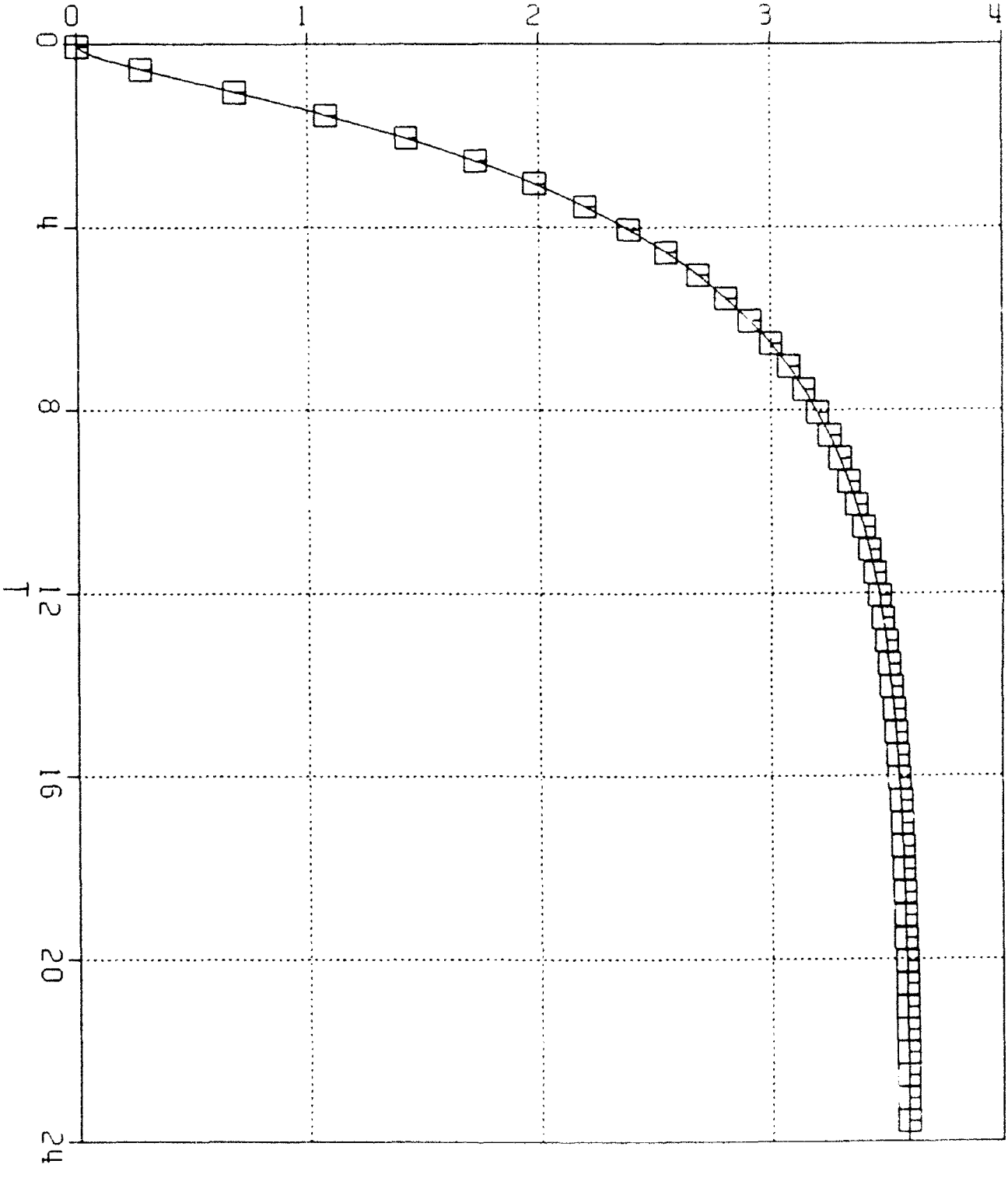
GRAPH 1



GRAPH 2



GRAPH 3



A Study of the Cytotoxic Effects of Trifluoroacetic acid on Rat Liver Cell Cultures

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August 1992

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Centerville High School

Abstract

A study of the toxic effects of Trifluoroacetic acid was accomplished on a cellular level. Earlier TFA work in this lab conducted experiments at levels around 500 ug/mL. Using information from those studies as a starting point, 500 ug/mL became the baseline concentration for the cytotoxicity assays. Through these tests, the concentration that resulted in 50% cell death (EC50) was found to be 20 times greater than the baseline concentration. At 500 ug/mL, cell damage seemed minor, with cell and protein growth between control and test cells roughly equivalent. According to an LDH/AST assay, TFA seems to have little effect on the cell membrane at concentrations between 250 and 1000 ug/mL. Interestingly, LDH leakage decreased slightly with the addition of TFA.

A Study of the Cyttoxic Effects of Trifluoroacetic Acid on Rat Liver Cell Cultures

Elizabeth A. Stoehr

Introduction

In an airplane, arguably the most dangerous situation is a fire while on flight. In an environment where the closest landing point and fire station are 2,000 feet straight down, an efficient method of fire control is necessary. In the past, halons (halon 1211 and 1301 especially) proved excellent fire extinguishers. Unfortunately, these chemicals are chlorofluorocarbons and are harmful to a rapidly depleting ozone layer. The Air Force is currently analyzing possible alternatives to halons including perfluorohexane (PFH) and hydrofluorocarbon (HCFC-123). Because of the push to find a replacement quickly, hazard assessment procedures must be accelerated. HCFC-123 is a very attractive candidate because of its structural similarities to Halothane, a common human anesthetic that has been studied in depth. One concern about HCFC-123, however, is its byproduct trifluoroacetic acid or TFA which can be extremely toxic at high concentrations. Earlier TFA researchers in this lab used 500 ug/mL concentrations in their work. To continue that trail of experimentation, the same TFA concentration was used as a baseline in this study.

Methodology

A: Care of Stock Cells

The cells used in this study were taken from the WB344 rat liver cell line. These cells were plated on Corning plastic 100mm plates. They were fed daily with complete medium (DMEM) consisting of minimum essential media supplemented with 1% MEM non-essential amino acids solution, 0.5% MEM vitamin solution, 1% MEM amino acids solution, 1% MEM sodium pyruvate solution, 2.2 mg/mL sodium bicarbonate (all above from Gibco), 4.2 mg/mL Hepes buffer (Boehringer Mannheim), and 5% Hyclone fetal bovine serum. It normally took 3-4 days for cells to reach confluence after a 1:40 split.

B: Finding the EC50

Using a sulforhodamine B assay (SRB), we collected enough data points to extrapolate the concentration necessary to reduce the intracellular protein synthesis by 50% (EC50). A confluent plate of cells was harvested (about 6-8 million cells per plate) and then diluted to 100,000 cells per mL. After removing the media, cells were washed with Dulbecco's phosphate buffered saline (DPBS) (Gibco), and trypsinized with Trypsin/EDTA (Boehringer Mannheim) for 5-10 minutes. Cells were transferred to centrifuge tubes for ease of pipetting and diluting. A cell sample was counted on a hemacytometer and then diluted to a 100,000 cells/mL dilution. Next, cells were plated out on a Corning, culture treated, flat bottom, 96 well plate with 200 uL DMEM per well. The first column on the plate (eight wells per column) was left blank to check the analyzing machine's accuracy. This plate contained 20,000 cells per well. For comparison, a

second plate was filled with 10,000 cells per well. To make this dilution, the remaining cell solution was diluted with DMEM in a 1:1 ratio and then plated out on the second plate. The two plates were incubated for three hours at 37°C in 5% CO_2. During this time, we made up the dilutions of TFA. We began by making a stock solution with the experiment's highest concentration of TFA, 2000 ug/mL, adjusted to a 7.1 pH. After the stock solution was made, mixing the lower dilutions was a simple process of adding stock solution to measured out vials of media. The following chart shows a breakdown of the dilutions:

ugTFA/mLDMEM	Stock	Media	Transfer	Transfer
2.0	50	0	6	50
1.0	4	6	6	12
0.5		6	6	12
0.25		6	4.5	12
0.125		4.5	3	9
0.0625		3		6

After the three hours, the media from the two 96 well plates was removed and replaced with the dilutions with one column per dilution. The last column was refilled with DMEM to act as the control column. The cells were then incubated for 24 hours. The following day, the SRB analysis was completed according to

standard protocol.

C: Protein Growth Between Control and Test Samples

Cells were grown in DMEM and DMEM + TFA. Each day, samples of the cells were counted and then frozen. These frozen cell samples were later analyzed with a Pierce BCA protain assay to calculate total protein content.

Two confluent cell plates were harvested and combined in a centrifuge tube. Cells were then counted on a Coulter counter and diluted to 100,000 cells/mL to be plated on 36, 100 mm, Corning, culture treated plates. Nine mL of DMEM was added to each plate, with one mL of the cell solution. Cells were allowed to attach for three hours in the incubator. After the incubation period, the media from all plates was removed, and 18 plates were replenished with DMEM while the other 18 were fed with DMEM containing 500 ug TFA/mL DMEM. This feeding time became a 24 hour timepoint. Every day at the timepoint, three DMEM plates and three DMEM + TFA plates were seperately harvested, counted, and centrifuged. The supernates were thrown out and the cell pellets were resuspended in 200 uL of DPBS. Cells were then placed in a centrifuge vial and frozen for a Pierce BCA analysis at the end of the assay. Cell plates were fed every other day with their respective media. After three days, both control and TFA plates attained confluence, and the experiment was ended after the fourth day. To quantitatively compare the protein growth between the cells treated with TFA and the control cells, a Pierce BCA protein analysis was completed according to standard

protocol.

D: LDH/AST Leakage At Different TFA Concentrations

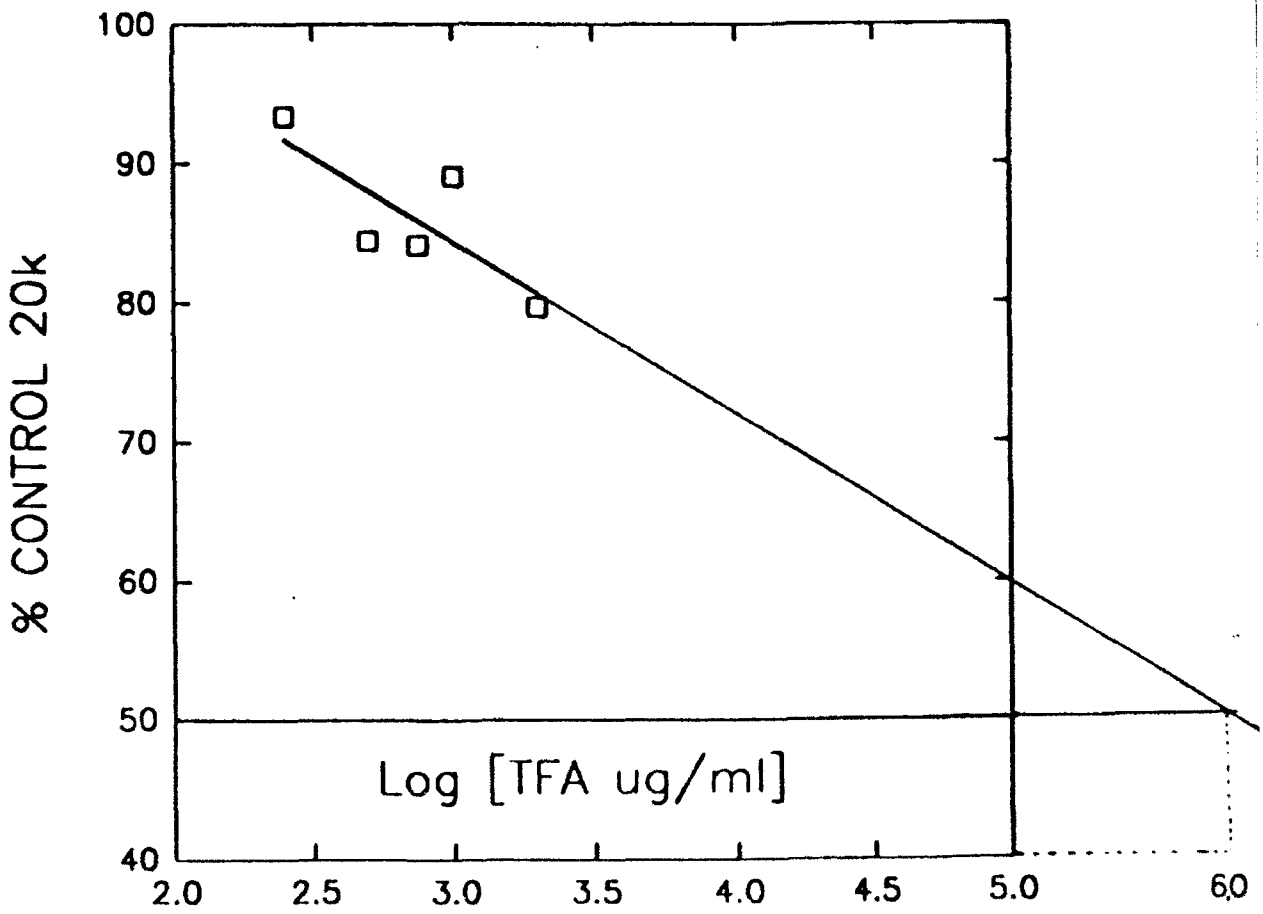
The final test I completed was a LDH/AST assay. LDH is a common cytoplasmic enzyme found in all cells. The LDH test examines a chemical's ability to damage cell membranes by comparing LDH leakage of control cells and cells treated with different concentrations of a chemical. AST is an enzyme found in mitochondria. Evidence of high AST leakage compared to a control sample signifies mitochondrial membrane damage. Samples of control and TFA contaminated cells were run throught the LDH/AST assay to examine membrane damage.

For the experiment, cells were first harvested from a confluent cell plate and then counted on a hemacytometer. For this assay, 300,000 cells per well for 12 wells were needed. After making 12 mL worth of *300,000 cells/mL* dilution, one mL of DMEM was added to each well along with one mL of the cell dilution. The cells were incubated for three hours to allow for attachment. After that time period, each well's media was replaced with a test concentration of TFA. Three wells were first labeled "Control" and replenished with DMEM. The TFA dilutions 250 ug/mL, 500 ug/mL and 1000 ug/mL were each allotted three wells on the two, six well, Corning, culture treated, cell plates. The cells incubated for another 24 hours to await the LDH/AST assay completed the following day.

Results

B: Finding the EC50

At concentration levels belos 250 ug TFA/mL DMEM, the level of tested cell protein was nearly equivalent to control cell protein levels. Above those concentrations, protein levels began to decrease. Even at 2000 ug/mL protein levels were 80% of control's, well above the EC50 line. By using the last five data points, we could construct a fitted line between the points and extrapolate the line to the 50% mark. The extrapolated line and 50% line intersected at about 10,000 ug/mL or .0877 Molar. This is 20 times the 500 ug TFA/ mL DMEM concentration level used as a baseline. Here is the graph for the 20,000 cells/well test plate. The 10,000 cells/ well graph was very similar.

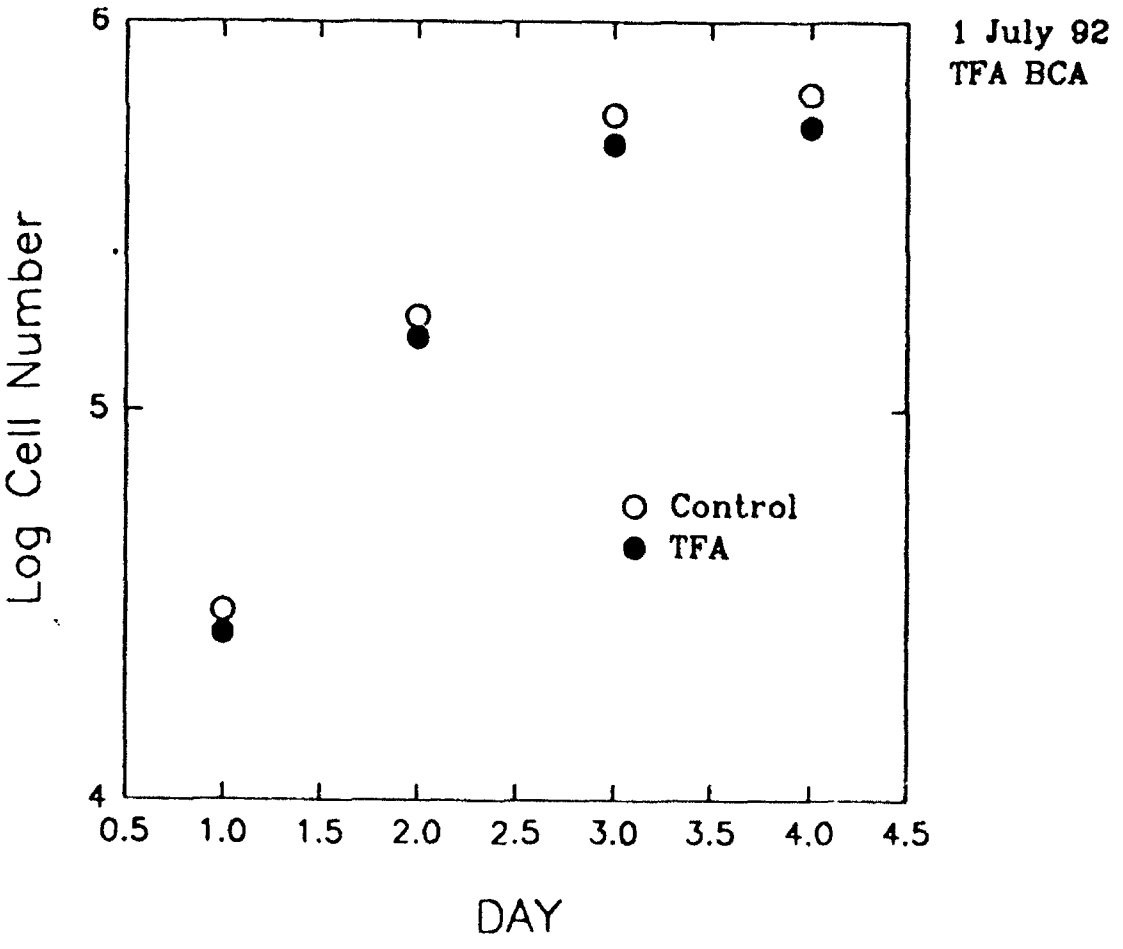


C: Protein Growth Between Control and Test Samples

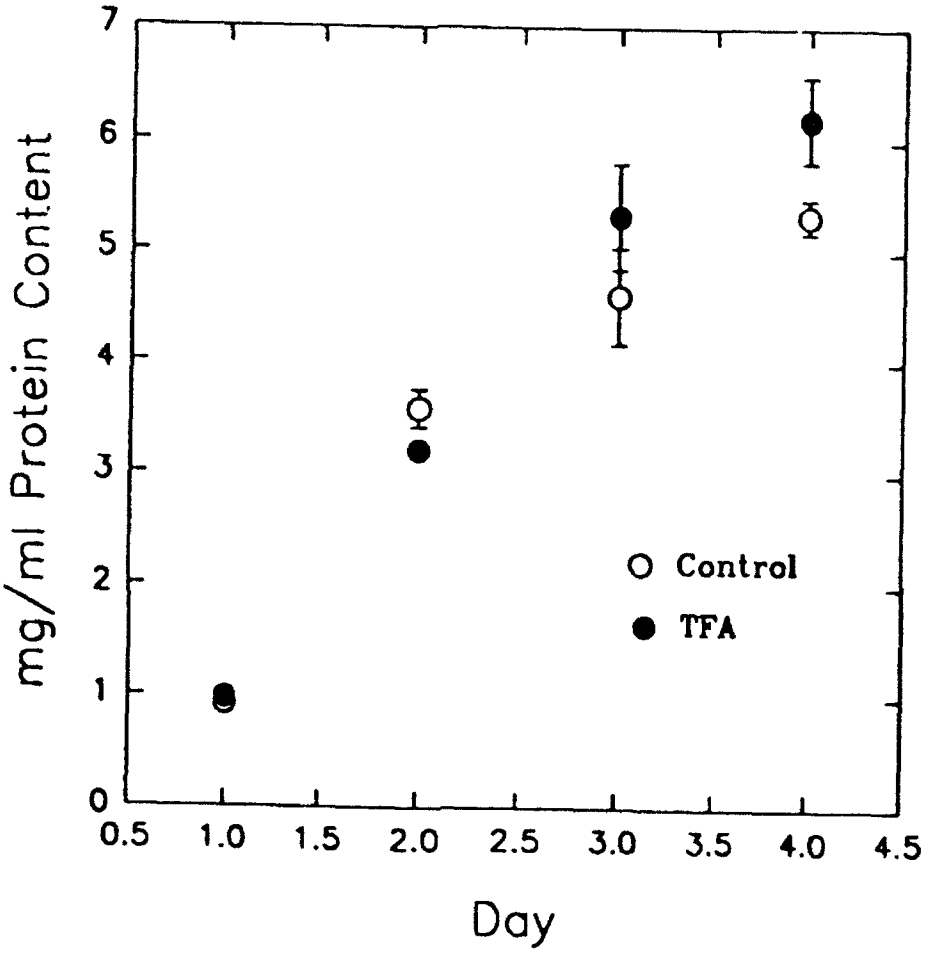
The cell counts showed more cells per mL growing on the control plates than on the TFA treated plates. The following data was collected:

Day	Control	TFA
1	30,800	26,973
2	175,922	154,578
3	577,867	482,978
4	652,622	796,800

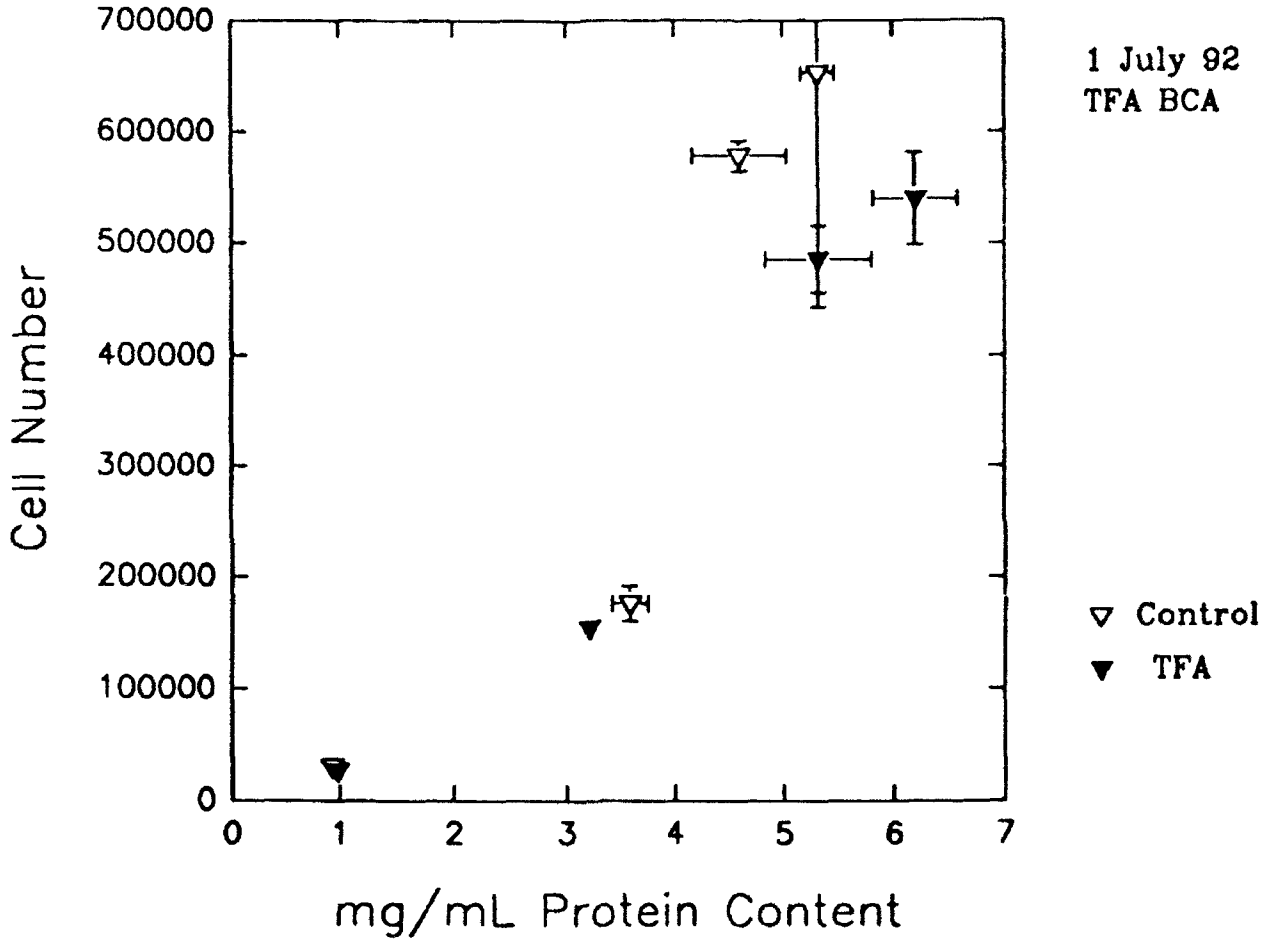
This graph compares cell number between control and test cells:



For living systems, the difference in cell number is slight. TFA treated cells also saw a higher level of protein growth than their respective controls. This becomes apparent in the following graph:

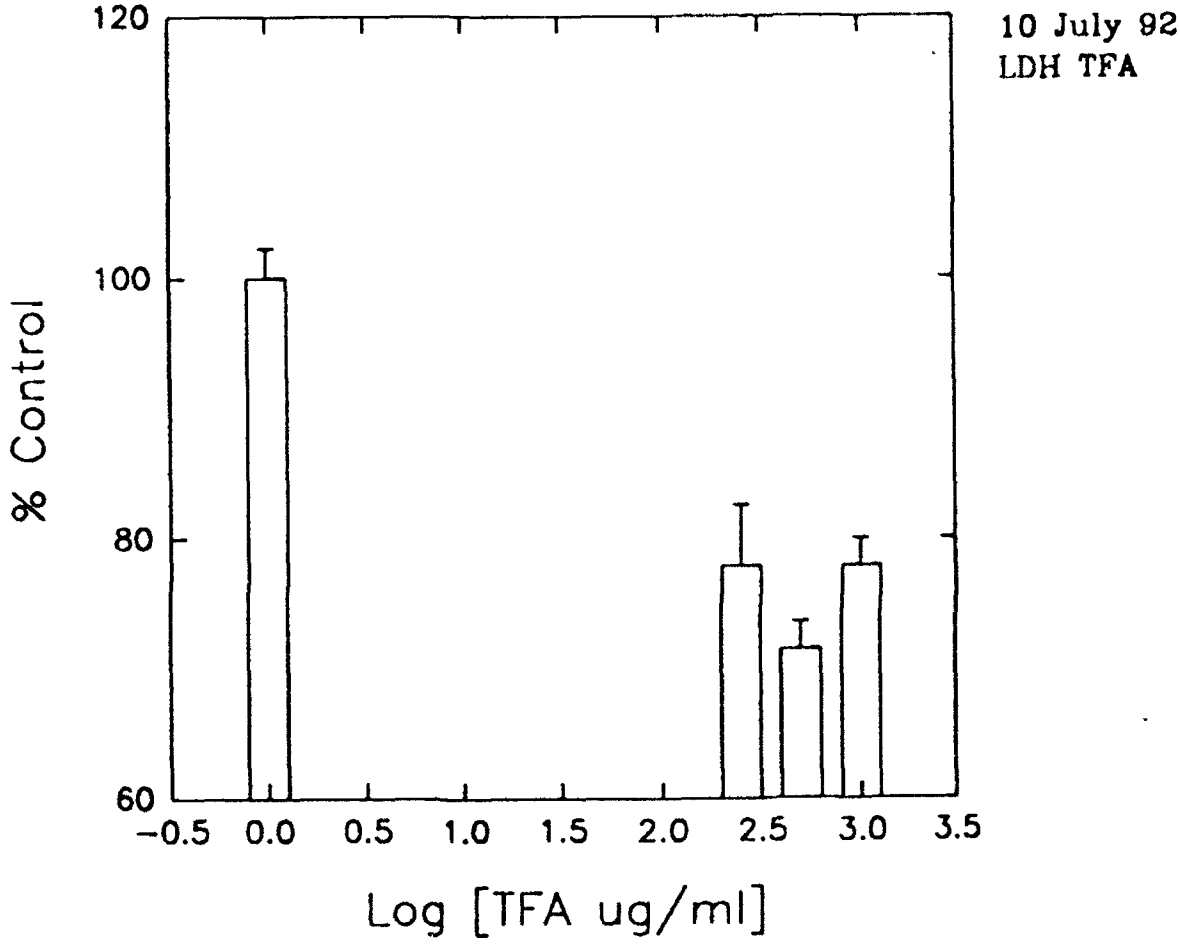


The following cell number versus protein concentration graph agian exemplifies the small effect TFA had on the cell cultures:

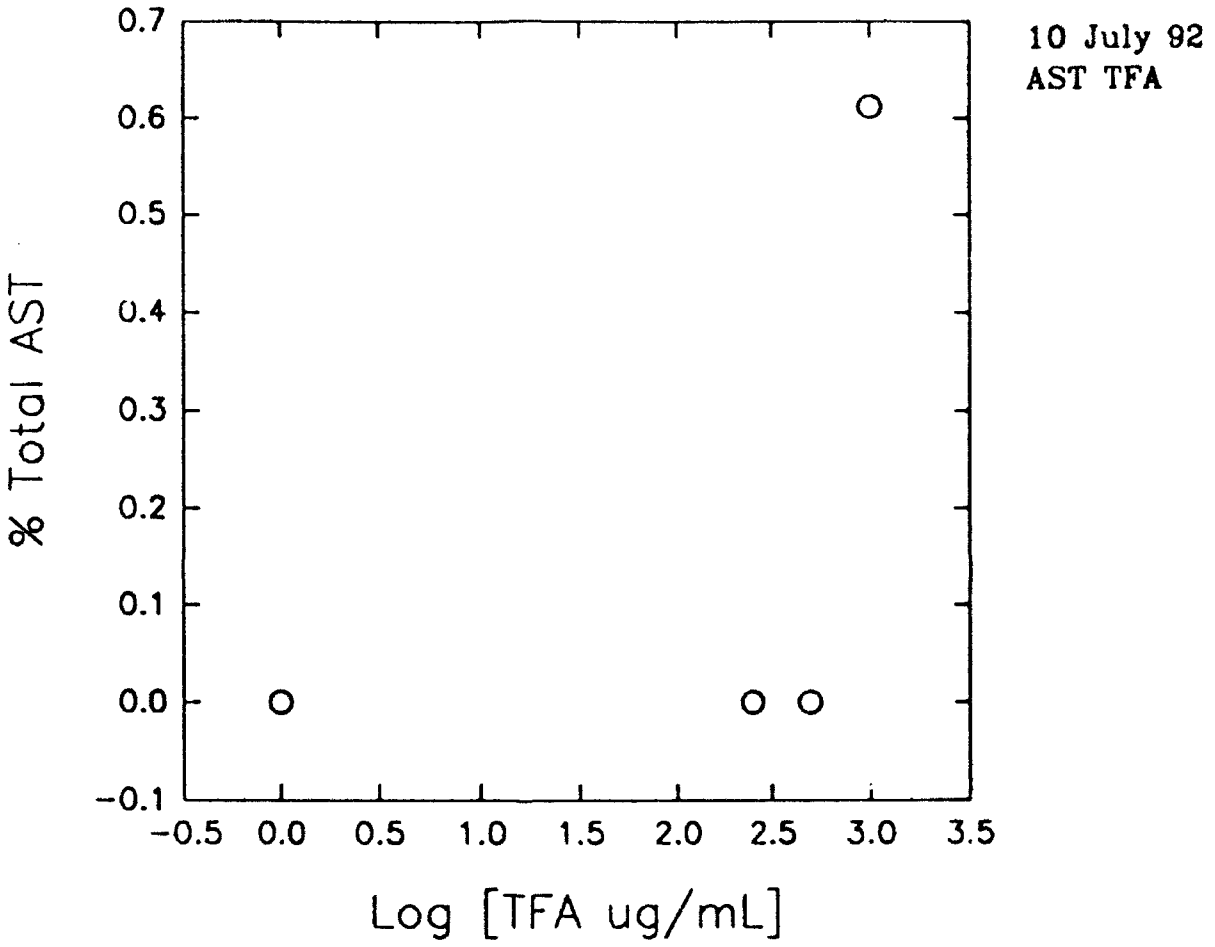

700000
600000
500000
400000
300000
200000
100000
0
Cell Number
0
1
2
3
4
5
6
7
mg/mL Protein Content
1 July 92
TFA BCA
Control
TFA

D: LDH/AST leakage

Surprisingly, LDH leakage fell with the addition of TFA. This is interesting because it is difficult to attribute the drop to cell death in light of the high cell survival rates in the BCA assay. This graph shows the drop in LDH leakage:



AST levels were meakedly elevated at the 1000 ug/mL mark as seen in the following chart:



TFA seems to be affecting the mitochondria even at one tenth of the calculated EC50.

Conclusion

Although this is only a small scale study, a few trends of TFA chemical behavior already seem visible. These early tests used to extrapolate the EC50 lay a foothold for future TFA studies at the expecetd EC50 level. The BCA test uncovered a growing cell population with falling intracellular protein concentrations in TFA treated cells compared to controls. BCA tests need to be accomplished at higher and lower concentrations to see if similar results occur. At the 500 ug TFA/mL DMEM, the differences between cell cultures still seemed minor and both groups of cells were definately healthy. The results of the LDH assay pose questions as to how TFA is decreasing LDH leakage at 500 ug/mL. More importantly, these results show that 500 ug TFA/mL DMEM is not severely damaging or impairing the cell membrane. Results from the AST assay also proved interesting. For the second time this lab has seen AST leakage markedly increasing under TFA induced stress. A comparative analysis between mitochondria of control and TFA treated cells is a worthwhile study. By staining mitochondria with the flourescent rhodamine 123 (R-123), rates of mitochondria destruction could be calculated. Cells cultured under different TFA concentrations and then harvested, counted and stained with R-123 could unveil some interesting and useful information about TFA's chemical characteristics.

TFA assuredly has other chemical properties under lab

conditions, let alone in the kind of environment during a fire situation. TFA also has its own biproducts that can be harmful and their cytotoxicity at effected levels also needs to be analyzed. Still, these first tests to study HCFC-123's metabolite, TFA, have uncovered no surprising harms.

DEVELOPING A USER'S GUIDE FOR AN INSTRUCTIONAL DESIGN PROGRAM

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Summer Research Program
Armstrong Laboratory

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Abstract

During the eight weeks I spent as an apprentice at Armstrong Laboratory, I learned to use several computer programs including word processors, graphics editors, and course design software. My main objective, however, was to develop a user's guide for the program Guided Approach: Instructional Design Advisor (GAIDA). GAIDA is a ToolBook program which runs under Windows 3.0 on Intel 80386/80486-based personal computers. GAIDA is used to provide guidance for the development of effective computer-based instruction (CBI).

DEVELOPING A USER'S GUIDE FOR AN INSTRUCTIONAL DESIGN PROGRAM

Kimberly Thompson

INTRODUCTION

There are a variety of means with which to teach students how to perform certain tasks, but many instructional designers have difficulties setting up effective lessons. The purpose of Guided Approach: Instructional Design Advisor (GAIDA) is to aid the instructional designer in the development of quality computer-based instruction (CBI) (Gagné, 1992). GAIDA is based on Prof. Robert M. Gagné's ideas and applies his Nine Events of Instruction (Gagné, Briggs, & Wager, 1992). These nine events are intended to tell the instructional designer what kinds of steps should be taken in order to properly instruct a student.

The user's guide I developed for GAIDA is meant to help an inexperienced instructional designer form an effective lesson. Due to my relative unfamiliarity with computers and their systems, I was considered a perfect example of a novice instructional designer. My task was to explain GAIDA in terms that could be readily understood by someone in a similar situation. By looking over the four worked cased within GAIDA, I was able to comprehend the ideas and motives of the program. Through my understanding, my ability to explain the many details of GAIDA, those both simple and complex, expanded considerably.

Included as an appendix in this report is a draft of the user's guide I developed for the GAIDA program. It is not considered a final draft due to the unfinished condition of GAIDA.

DISCUSSION OF WORK

GAIDA is part of a larger Armstrong Laboratory project called Advanced Instructional Design Advisor (AIDA) (Gagné, Tennyson, & Gettman, 1991). The GAIDA program has four completely worked cases which detail four separate learning

objectives. These cases are ordered from simple to complex concepts and involve practical applications of the GAIDA program. The user can view these cases in order to better understand how GAIDA can be applied in teaching situations.

The first case involves the identification of naval ranks. By presenting the user with a hypothetical situation which conveys the relevance of learning the ranks, the user responds more readily to the written instructions and graphics.

In the second case, the process by which resistors are classified is explained. The use of color charts and diagrams elaborates this process to the user more completely. A test at the end of the lesson reiterates the lesson that is being taught.

The next case requires the user to learn how to run a systems check of the M61A1 gun, which is the gun in the F-16 aircraft. Through the use of a checklist, the user completes the thirty-two steps in the procedure. The aim of this lesson is to teach the user to use written instructions and a checklist to execute the task.

The last case, the pulmonary function test, uses detailed instructions which are designed to teach the user a procedure which must be memorized. The written instructions and graphics present in this lesson are implemented in such a way that will guide the user to produce quality CBI.

CONCLUSION

GAIDA provides an opportunity for a novice instructional designer to form complete, effective lessons that a student can easily understand. The lessons within GAIDA may not be identical, or even similar, to what a user wants to teach a student, but the step-by-step guidance in those lessons is applicable in different types of situations.

Through my experiences with GAIDA, I was able to learn to use a variety of computer programs, such as WordPerfect, ToolBook, and Harvard Graphics. The time I spent at the Instructional Design Branch (HRTC) of the Training Research

Division at Brooks Air Force Base was enlightening. My task was quite compelling, and, at times, exceptionally challenging, so I always remained interested. I enjoyed my time as a research apprentice, and I felt as if what I accomplished had a direct and positive impact on the work being done.

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Gagné, R.M., Tennyson, R.D., & Gettman, D.J. (Dec. 1991). Designing an advanced instructional design advisor: Conceptual frameworks. Brooks AFB, TX: Armstrong Laboratory, Human Resources Directorate(AL-TP-1991-0017-Vol-5).

APPENDIX

GAIDA--User's Guide

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--Lesson Generation Mode

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Section 5
Classification

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2. Illustrative screen for event number three.
3. Color chart and diagram for resistors lesson.
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8. Event number four for pulmonary function test.

INTRODUCTION

Guided Approach: Instructional Design Advisor (GAIDA) is a PC program which provides guidance for developing effective computer-based instruction (CBI). Based on Prof. Robert M. Gagné's ideas, GAIDA guides a novice instructional designer through the steps necessary to create quality CBI. GAIDA utilizes Gagné's nine events of instruction, which are meant to tell the designer what types of events are appropriate for achieving desired learning outcomes (1985). These nine events are as follows:

1> Gain Attention
2> Describe the Goal
3> Stimulate Recall of Prior Knowledge
4> Present the Material to be Learned
5> Provide Guidance for Learning
6> Check Performance
7> Give Informative Feedback
8> Assess Performance
9> Enhance Retention and Transfer

Within GAIDA there are four completely worked cases displaying how these nine events can be effectively applied in four different situations. These examples involve different learning objectives and subject matter, yet all follow Gagné's nine events. The four cases involve an identification objective, a classification objective, and two different kinds of procedural objectives. The subject matter includes naval insignia, electronic components, aircraft weapons, and medical testing. This variety of cases is intended to represent a broad range of technical training situations.

In the first case, the identification of naval ranks is involved. The written instruction in this example is concise and gets the user's attention immediately. By slowly introducing the

ranks in small groups and describing each rank in detail, the lesson enables the user to identify all of the ranks. Small quizzes throughout the lesson further enhance the user's knowledge.

The second example explains the process by which resistors are identified and classified. Through the use of color charts and diagrams, the user learns how to test the resistance of these resistors. There is a test at the end of this lesson as well.

In the procedure called "Functional Check of the M61A1 Gun" (the gun in the F-16 aircraft), the goal is for the user to learn how to run a systems check of the gun. By using a checklist, the user goes through the thirty-two steps in the procedure. This example is designed to teach the user to use written instruction and a checklist to perform the required task. Essential to this instruction is the capability to recognize important steps in the checklist and to learn appropriate actions should a particular problem occur.

The last example is the pulmonary function test. This procedure uses explicit instructions designed to teach a procedure that must be committed to memory. The example includes a sample lesson which gives the user a good base with which to begin forming a lesson. By using graphics as well as written instruction, the pulmonary function test guides the user through the steps necessary to produce quality CBI.

These cases offer detailed applications of GAIDA's capabilities, and they are all of benefit to an inexperienced instructional designer. By using Gagné's nine events of instruction, the user learns how to make concise, effective lessons in a variety of situations. With the help of some written instruction and elaborative graphics, the user can become proficient at designing and developing effective CBI.

Gagné's nine events of instruction are intended to give the novice instructional designer a step-by-step guide to forming a complete lesson. Each event has a specific purpose and targets a certain element of the learning process.

In the first event, "Gaining Attention", various interesting stages are used to gain the student's willing attention. Such things as unusual phrases and eye-catching graphics are usually very effective.

"Describing the Goal", the second event, is basically short and simple, but it is still necessary. Rather than assume that the student knows what the objective of the lesson is, the instructional designer should take a moment to explain what the student is expected to accomplish. By using words and pictures that the student can easily understand, the user can be sure that the goal is effectively communicated to the student.

In order to "Stimulate the Recall of Prior Knowledge", the user must present a question or problem to the student which requires the student to call upon some previously learned subject. The user, by having the student recall something relevant to the new subject being learned, is giving the student a base to which further knowledge can be added.

The next event, "Present the Material to be Learned", has a rather obvious purpose. Whatever the student is required to learn, whether it is a naval rank or a step in a checklist, is presented in this event. The use of pictures or diagrams is helpful, as well as oral or written information which is necessary for the student to know.

The next event, "Provide Guidance for Learning", involves questioning the student on certain concepts that he or she should be learning. By making hints available, the user is giving the student chances to be aware of which facts are important and, therefore, necessary to know.

In the event titled "Check Performance" the user does

exactly that. Small quizzes at the end of each lesson require the student to know certain key facts. The user can ascertain how much the student has learned and how effective the lesson is by having the student display what has been learned.

The next event is "Give Informative Feedback". This event involves the user's response to the correctness of the student's answers to the questions. It is important for the student to receive some sort of feedback. By offering such guidance, the user is giving the student an indication of how correct his or her performance is. Without this essential feedback, the student would not be aware of any mistakes he or she has made and, consequently, would not be able to correct these mistakes.

The event titled "Assess Performance" is the step the user must take to test the validity of the student's answers. The assumption cannot be made that the student, upon giving a single correct answer, has learned the lesson. By asking the same sort of questions but using different instances, the user can make sure the student understands the lesson completely.

The last event, titled "Enhance Retention and Transfer", reviews the concepts within the lesson and offers a variety of applications which are relevant to those concepts. The student's understanding of the relevance of the different situations to the ideas learned is the goal of this event.

SECTION 3

Within GAIDA, there are two modes available to the user, the guidance mode and the lesson view mode. Each mode has a singular function and can be used in an easily understood and useful manner.

The guidance mode has two main parts: a text section and a graphics section. In the text section, the user gives the instructions, facts, and any other printed information that it is necessary for the student to learn. The graphics section

contains various pictures, diagrams, and/or charts in which the printed information is further elaborated.

The lesson view mode is basically similar to the guidance mode except that, quite obviously, in it the user is able to view entire lessons. The pages of this mode are generally like those pages in the guidance mode in that there is a text section and a graphics section. However, in this mode there is a lesson control menu that enables the user to choose what he or she wishes to make a lesson.

SECTION 4

In the first procedure, the user's goal is to identify naval ranks. This example's purpose is to show the instructional designer how to form a lesson that will teach the user to accurately identify objects. By presenting a hypothetical situation in which it would be necessary for the user to know certain naval ranks, the example begins with a motivational purpose.

The identification example introduces the ranks and explains each one in detail, but it does this in small groups of three or four at a time. By giving the user time to absorb the information and further enhancing all the details with small quizzes after each group, this example creates a simple but effective learning environment.

SECTION 5

In the second procedure, the user must classify certain electronic components known as resistors. The purpose of this example is for the instructional designer to learn how to create a lesson that teaches the user to classify certain objects. Classifying is slightly more complex than identifying because it includes taking an action or following a rule vased on a

successful identification.

This procedure explains how resistors are classified and why their classification is important. There are color charts and numerous resistor diagrams that help the user to understand exactly how to classify resistors. The problems within this example give the student opportunities to practice the classification procedure. There is a test at the end of the lesson that requires the student to classify seven resistors in the correct order before the lesson can be considered complete.

SECTION 6

In the checklist procedure example, the student's goal is to use a checklist to run a systems check of a gun found in the F-16 aircraft. The purpose is for an instructional designer to learn how to form a lesson that will teach the user to follow the steps in a certain checklist.

In the procedure, there are thirty-two steps which the student must follow. Each step is detailed by written instructions and diagrams which completely explain everything the student needs to do. There are short quizzes within the lesson that describe a problem and offer the student a choice of a few solutions. These quizzes give the student a chance to apply what he or she has learned in the lesson.

SECTION 7

The memory procedure example is the pulmonary function test. This procedure offers more explicit and complex details than the other examples, yet it is still understandable by a novice instructional designer as it applies to the same nine events of instruction.

This procedure instructs the user on the proper way to

administer a pulmonary function test on a patient. It gives step-by-step guidance by showing diagrams and sample charts that can be used for quick reference. The sample lesson uses all of the options available within GAIDA; therefore, it gives the instructional designer a good idea how to form an effective original lesson.

SECTION 8

The GAIDA program is a means for a novice instructional designer to form a complete lesson that will effectively teach a student. The concepts within such a lesson may range from simple to complex, but GAIDA always provides an understandable format for explaining those concepts. Though the student may be inexperienced in the area in which a lesson is geared, the step-by-step guidance within GAIDA provides a detailed and easily interpreted method of instruction.

The four worked cased in this program give the user a sampling of what can be achieved through the application of GAIDA as well as some original ideas. As each example progresses, so does the comprehension of the user and, consequently, that of the student, as well.

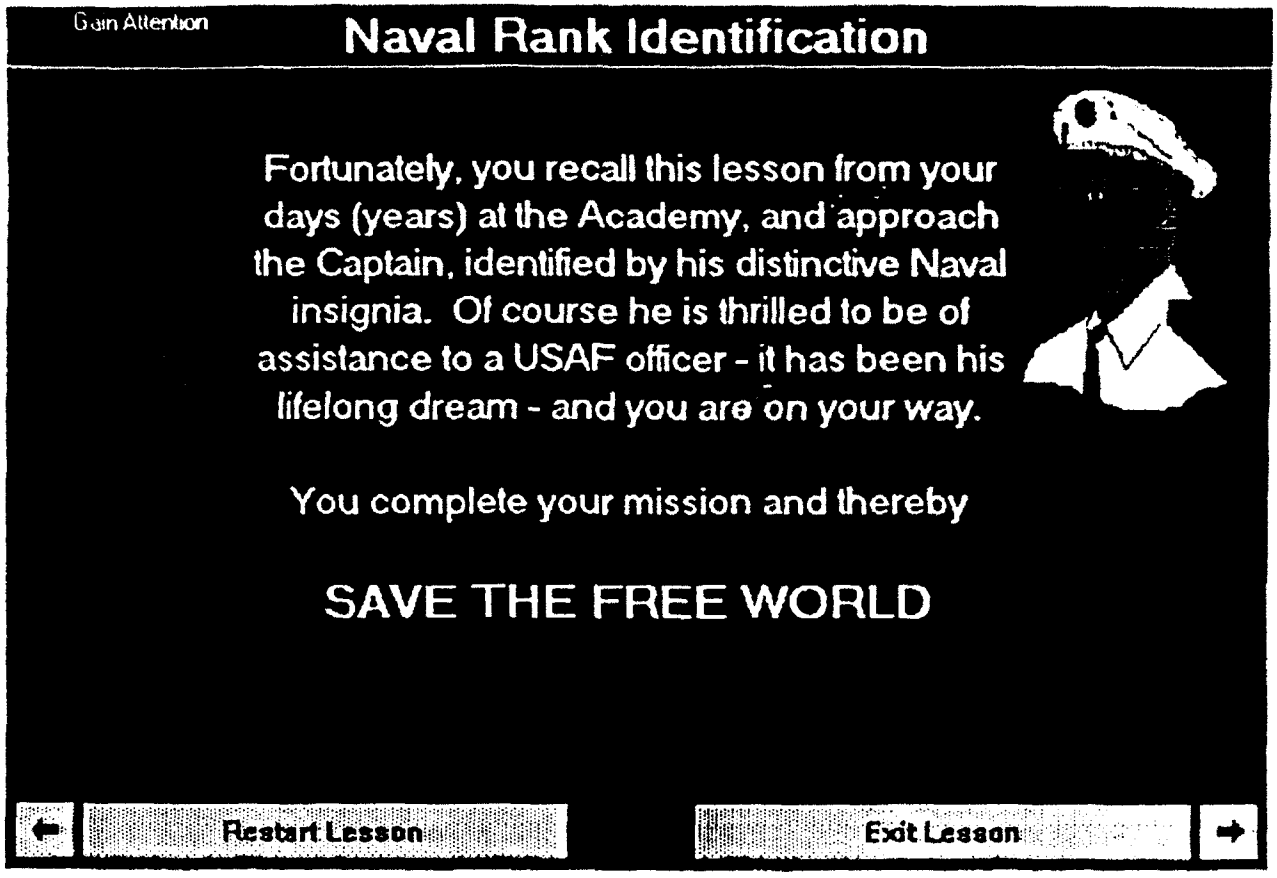

Figure 1. "Gaining Attention" screen of first lesson.

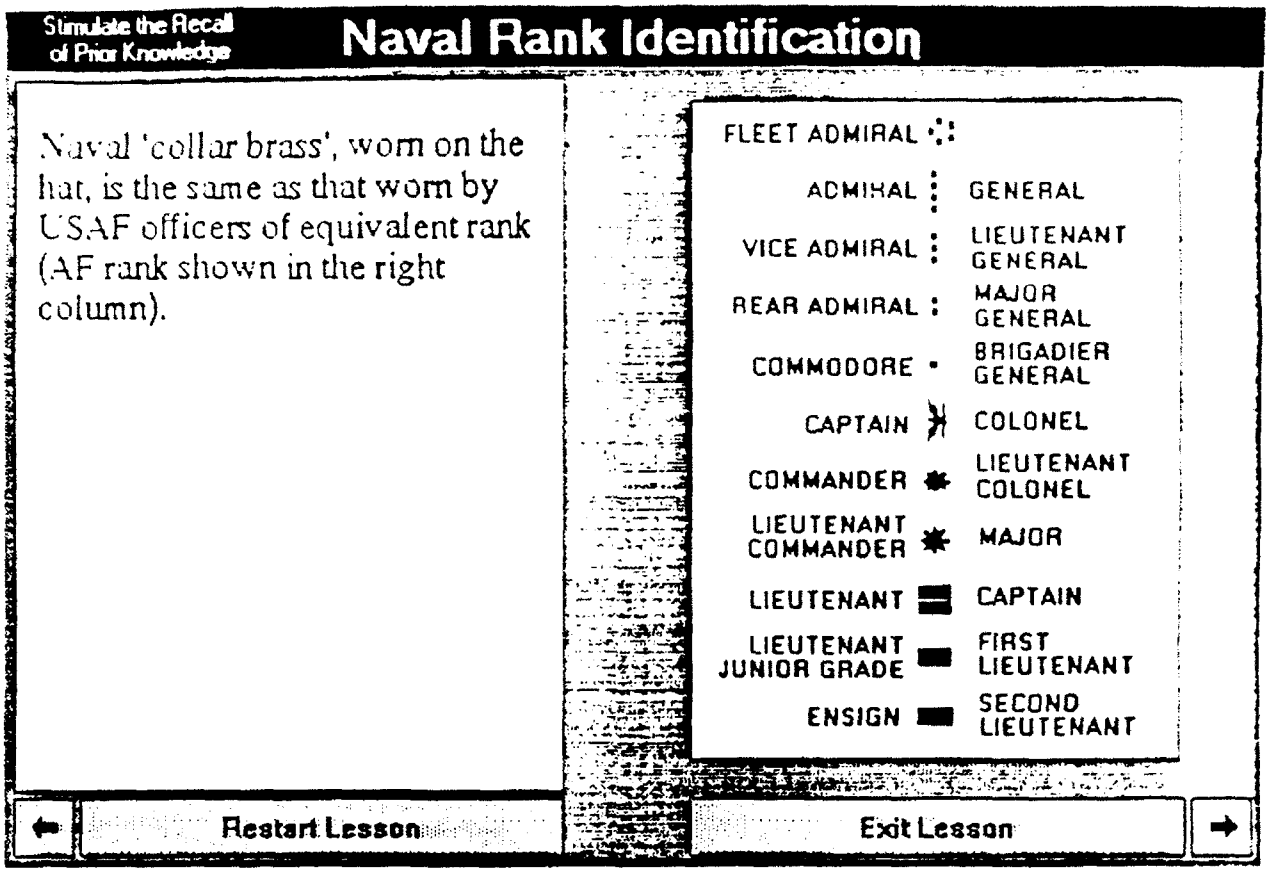

Figure 2. Illustrative screen for event number three.

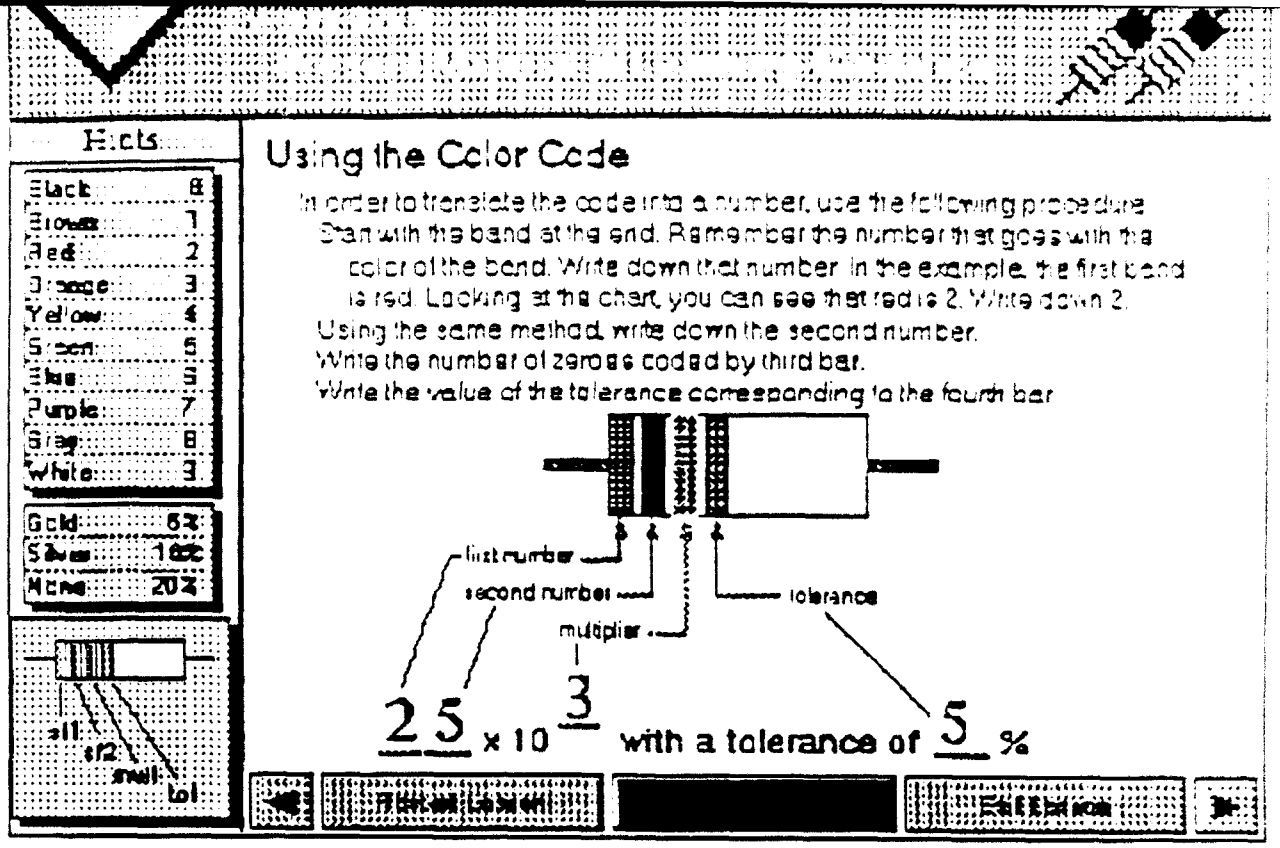

Figure 3. Color chart and diagram for resistors lesson.

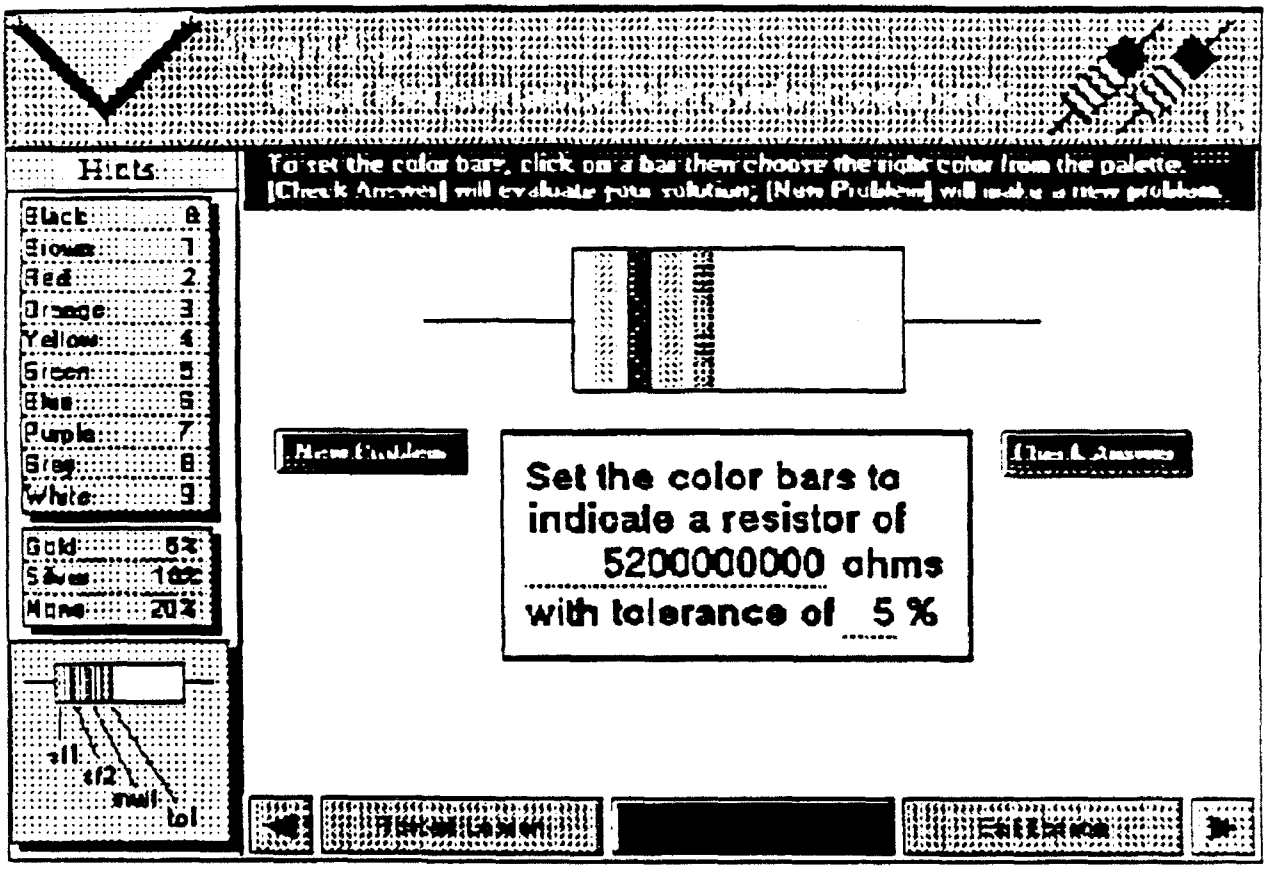

Figure 4. Short quiz section for resistors lesson.

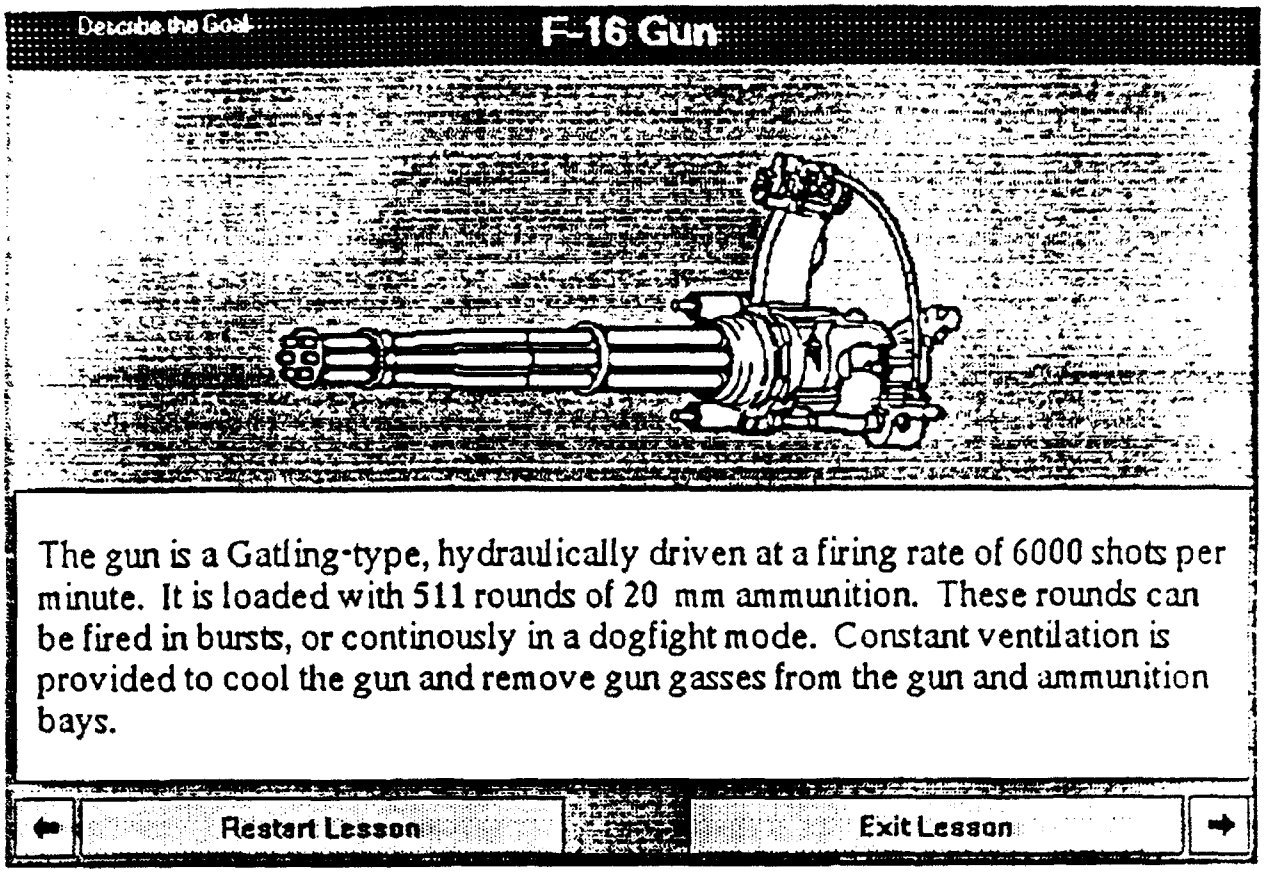

Figure 5. Diagram of gun in checklist lesson.

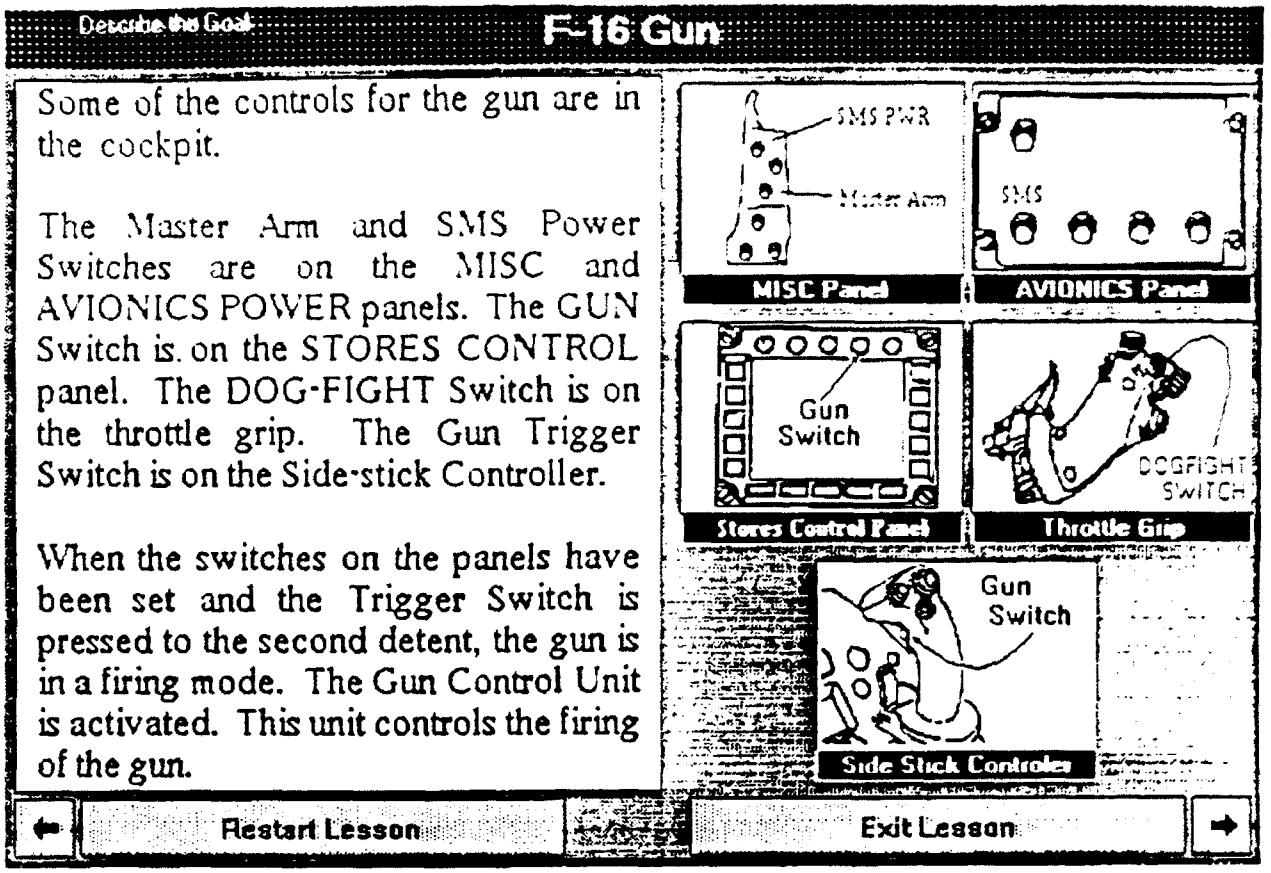

Figure 6. Diagrams of instruments in F-16 aircraft.

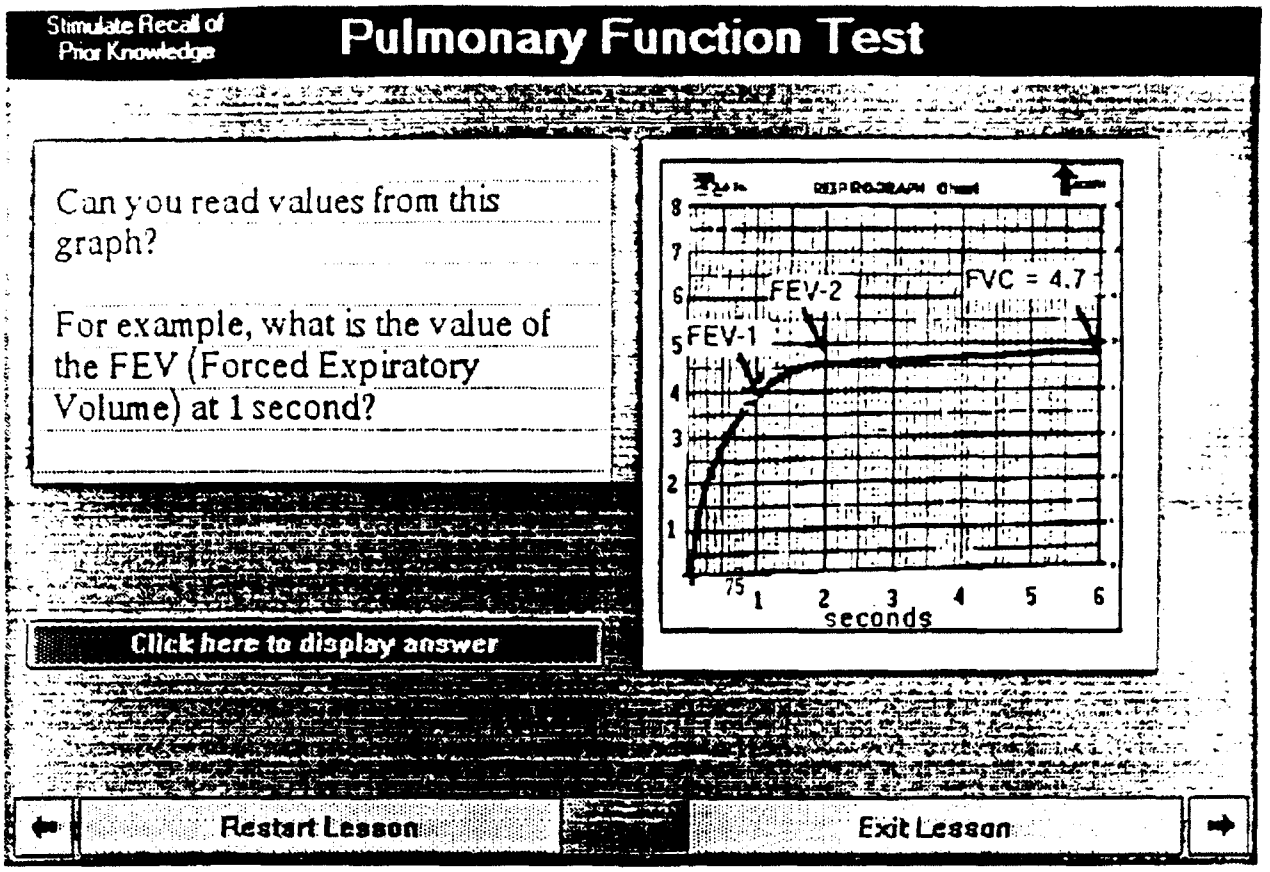

Figure 7. Respirograph chart diagram for memorization lesson.

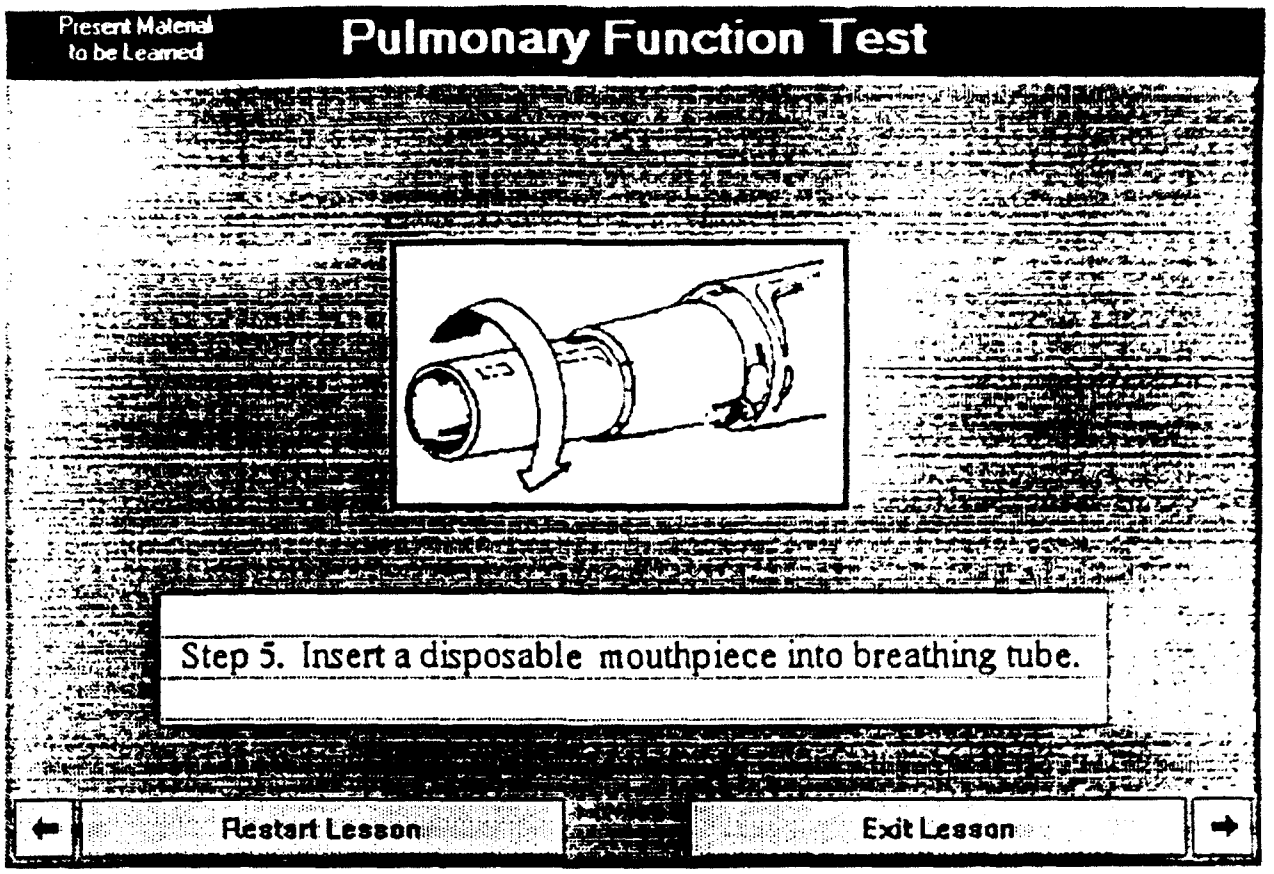

Figure 8. Event number four for pulmonary function test.

A CROSS VALIDATION OF THE CYCLE ERGOMETRY FITNESS TEST

Christopher J. Troyer

Final Report for:
Summer Research Program
Armstrong Laboratory
Brooks Air Force Base, San Antonio, TX

Sponsored by:
Air Force Office of Scientific Research
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August 1992

A CROSS VALIDATION OF THE CYCLE ERGOMETRY FITNESS TEST

Christopher J. Troyer

Abstract

The Air Force will be implementing a new fitness test in October of this year to evaluate the fitness of its personnel. This test will be a modification of the cycle ergometry test first developed by Astrand in the 1950's. Many individuals who cannot pass the cycle ergometry test have complained that in past years they easily passed the Air Force's old fitness test, a timed 1½ mile run. The validity of cycle ergometry as an estimate of fitness has therefore been questioned. This study concludes that the cycle ergometry test correctly classifies individuals according to his or her true fitness. Two groups, classified as fit and low fit by previous cycle ergometry tests, were compared on the basis of performance during a maximal run and a submaximal run. It is concluded that the complaints are based on misconceptions about cycle ergometry and on difficulties in adjusting to this new method of testing. This study shows that the cycle ergometry test is a good indicator of relative fitness and that its results are directly comparable to performance on the traditional 1½ mile run that it replaces for Air Force fitness testing.

A CROSS VALIDATION OF THE CYCLE ERGOMETRY FITNESS TEST

Christopher J. Troyer

Introduction

Maximal oxygen uptake has long been known by physiologists to be the best indicator of a person's ability to sustain hard work. It is also a good indicator of an individual's cardiovascular fitness.[1] Maximal oxygen consumption, or maximal oxygen uptake ($VO_{2\ max}$), is a measure of a person's ability to perform sustained work or exercise for relatively long periods of time. $VO_{2\ max}$ is also referred to as maximum aerobic capacity. Specifically, it is the point at which the oxygen consumption of an individual plateaus and shows no further increase with an additional workload.[2] In other words, it is the point at which the body can take in and process no more oxygen. Once this point is reached, the body must produce energy with anaerobic processes such as glycolysis as opposed to oxidative phosphorylation. These anaerobic processes build up lactic acid and will exhaust an individual very quickly, forcing him or her to discontinue exertion. A person with a high $VO_{2\ max}$ is able to transport oxygen to working muscles more efficiently and at a slower heart rate than a low fit person.[3] The higher the $VO_{2\ max}$, the longer an individual can sustain vigorous work.

Maximum aerobic capacity can be measured using either maximal or submaximal tests. Maximal tests are more precise tests. In a maximal test, the subject is pushed to exhaustion. At the point when the subject can complete no more intervals of exercise, the subject's heart rate and workload are

recorded. These can be used to estimate the subject's maximum aerobic capacity. In the late 1950's, Astrand and Rhyming developed a nomogram used by physiologists to estimate maximum oxygen uptake (in liters) using the relationship of heart rate to workload. Maximum aerobic capacity can be accurately measured by measuring expired oxygen and carbon dioxide concentration in a Douglas bag. This method measures the amount of oxygen utilized during the last minute of exercise before exhaustion. The Douglas bag method is the preferred method, but for large groups, it is simply impractical. It requires a lot of effort from the subject and a great deal of time to complete. It also involves expensive lab procedures and support.

For large groups, submaximal testing is much more practical. It isn't as reliable as maximal testing, but it is less stressful for the subject and is less time consuming. Submaximal testing predicts $VO_{2\ max}$ based on the subject's steady state heart rate response to a light to moderate workload. Astrand's nomogram is used for these estimations. Submaximal testing is associated with a 10% prediction error, but it is often felt that the time and effort saved by this type of testing is worthwhile.[4,5]

The sources of error in submaximal testing stem from assumptions about the relationship of heart rate to workload. There are three basic assumptions contributing to errors in the VO_2 estimate. The first assumption that produces error is that heart rate and oxygen uptake increase in a parallel fashion to workload applied. This is not the case for all individuals. In some individuals, the parallel lines of oxygen consumption and heart rate diverge as work becomes very hard. The slope of the line defined by heart rate or oxygen consumption to workload can also vary. The second source of error stems from the fact that as people age, their maximal heart rate

decreases. Irma Astrand corrected this error in P.O. Astrand's original nomogram by adding an age correction factor.[6] The last source of error occurs when oxygen uptake is predicted from the workload. A fixed mechanical efficiency is assumed for all subjects. This means it is assumed that two subjects can pedal on the cycle ergometer with the same efficiency from the energy they use. This is not the case - mechanical efficiency on a bicycle ergometer can vary by as much as 6%.[7]

Maximal oxygen uptake is usually measured while performing a task that involves a rhythmic use of major muscle groups (i.e. running or bicycling). These tasks are usually difficult enough to force the subject to produce energy by oxidative phosphorylation.[8] The two most common methods used to measure an individual's maximum aerobic capacity are treadmill and bicycle ergometer testing. The treadmill can be used for both maximal and submaximal tests while the bicycle ergometer is mostly used for submaximal tests. This is because the treadmill allows a true maximum effort to be attained much more easily than a bicycle. The bicycle ergometer test results in a $VO_{2\ max}$ up to 8% below that given by the treadmill during maximal tests,[9,10] and some investigators report that the ergometer test developed by Astrand underestimates the aerobic capacity of the very fit and overestimates the aerobic capacity of the low fit by as much as 17%.[11] It has also been reported that athletes trained in a certain mode of exercise can attain a higher $VO_{2\ max}$ in their own mode of training during a maximal test.[12] This supports the claim that bicyclists perform somewhat better on the cycle ergometry test than other athletes. However, the Air Force is using a submaximal test and there is little information reported on the effect of training specificity during submaximal tests.[13]

Up until very recently, the Air Force has assessed the fitness of its personnel by using a 1½ mile run. The run test was originally designed to be a timed twelve minute run in which the participants run as far as they can in twelve minutes. The distance covered correlated with maximal oxygen consumption and thereby stood as an estimate of fitness.[14] In the Air Force, the Copper twelve minute run test has evolved into an annual 1½ mile run. Participants are encouraged to run as fast as they can to complete the 1½ miles within age and sex specific time limits. Safety and other concerns prompted adjusting time limits until it became a measure of motivation instead of fitness. If one didn't complete the run within the allotted time, he or she faced certain consequences. Some participants reached dangerously high heart rates due to overexertion and had to be treated after the run. A number of cardiovascular events (heart attacks, etc.) and deaths have been associated with the annual run. Passing the run became more of an annual survival test with no incentive to lead a fit lifestyle. Based on recent studies of Air Force personnel, only one-third of them will be able to meet proposed standards for the cycle ergometry test when it is implemented in October of this year.[15] Many of those who fail to meet the cycle ergometry fitness standards observe that they always passed the run test easily. They complain that the cycle ergometry test must not be an accurate test of fitness. A study was needed to cross validate the cycle ergometry test using the old 1½ mile run test. This preliminary study was designed to show that the cycle ergometry test gives a good comparative measure of fitness between two people that correlates with performance on a 1½ mile run.

Methods

Subjects

Subjects were recruited from the active duty population of Brooks Air Force Base with the exception of one civilian employee. The size of the study limited us to male subjects. Subjects were paired to allow comparisons to be made between individuals. The stringent matching criteria would have made it difficult to pair subjects from the limited pool of females. The pairs were matched according to age (± 4 years), height (± 4 inches), weight (± 22 lbs), and reported activity levels. The only significant dependent variable that differed within each pair was the cycle ergometry score. One individual in the matched pair did well on the cycle ergometry test (category IV or better according to Air Force standards) and one did poorly (category III or less). These were the criteria used to classify individuals as fit and low fit. Once subject pairs were identified, they were recruited to participate in the study by phone. Not everyone contacted volunteered for the study. Eight individuals were recruited, resulting in four matched pairs. Two pairs were "inactive" and two pairs were "active" according to questionnaires administered at the time of their last cycle ergometry test.

Procedure

Each subject completed a maximal 1½ mile run, a submaximal 1½ mile run, and a submaximal cycle test on three days of his choice. Run tests were usually scheduled for early morning, between 7:30 and 9:00, when temperatures were relatively cool. The first test was a maximal 1½ mile run. The subject wore a Polar heart rate monitor while running and was encouraged to give a

maximal effort in order to achieve the best time possible. The subject's heart rate was recorded every eighth of a mile as the subject passed the investigator or a third person designated by the investigator to help record the heart rates. The split time was recorded every quarter of a mile as the subject passed the starting line. The subject's recovery heart rate was also recorded for five minutes after the completion of the run . The second session was a submaximal 1½ mile run. This was conducted on a different day than the maximal run to allow ample recovery. For the submaximal run, each individual was asked to pace himself in order to maintain a steady state heart rate as close as possible to 85% of his predicted maximum heart rate. Eighty-five percent is commonly used as a guide for submaximal testing and conditioning. The heart rate was again recorded every eighth of a mile and the split time taken every quarter of a mile. Recovery heart rates were also recorded. The last session was the same cycle ergometry test that has been adopted by the Air Force as its new physical fitness test. This was conducted on a day when the subject was well rested. The subject wore the Polar heart rate monitor while pedalling at fifty revolutions per minute on a Monark bicycle ergometer for a period of 6-7 minutes. The workloads selected were based on the subject's previous cycle test results and were intended to confirm the reproducibility of prior cycle tests. Heart rate was recorded every minute and entered into the Air Force's cycle ergometry computer program. The program uses this information to calculate each subject's predicted maximum aerobic capacity. The formulas used by the computer for the calculations are as follows:

W = weight in kilograms

H = height in centimeters

L = final workload in KP-meter/min [L = WL(KP) * 300]

AGE = age in years

HR = average heart rate for the last two minutes of the cycle test

1. A → **work performed** (amount of oxygen used)

   Body Surface Area (BSA) = $(W^{.5}) * (H^{.75}) * .004591$

   A = [L * 10.18) + (670 * BSA)]/5

2. B → **heart rate constant**

   B = (205 - 61)/(HR -61)

3. C → **age correction factor**

   C = 100/(100 +(1.37 * AGE - 33.2))

4. **Raw aerobic capacity**

   VO_2(ml/min) = A * B * C

5. **Estimate of maximum aerobic capacity** (ml O_2/kg/min)

   $VO_{2\ max} = VO_2/W$

These formulas developed by Dr. Loren Myhre at the Armstrong Laboratory correlate very highly with scores obtained by direct estimation using the Astrand nomogram.

The average heart rates and split times during the maximal and submaximal runs of the groups were compared. The averages from the maximal run are graphed later in this paper. $VO_{2\ max}$ was estimated using the heart rate averages from the submaximal runs. The first step was to find the average

time it took each group to complete one mile. This was then converted to miles per hour for both groups. A chart was used from The Textbook of Work Physiology by Per-Olaf Astrand and Kaare Rodahl to convert mph to kpm (kilopond meters). Astrand's nomogram was then used to estimate liters of oxygen consumption. Finally, a table from Astrand's and Rodahl's book was used to convert $VO_{2\ max}$ in liters to $VO_{2\ max}$ in ml/(kg*min), the unit normally used. An age correction factor was not needed because the average age of the subjects involved was 24. An age correction factor is not needed at this age because the predicted maximum heart rate possible has not declined.[16]

Results

Table 1 shows the demographics of the subjects used for this study.

Table 1: Subject Demographics

	Age	Height (inches)	Weight (lbs)
Average	24	70.56	172.25
Range	18-28	68-74	143-198

All subjects completed a 1½ mile maximal run and a 1½ mile submaximal run. Figure 1 shows the relationship between time and heart rate for both groups during the maximal run. Despite the fact that the heart rates of both groups follow the same upward curve, it can be seen that at any given time, the average heart rate for the fit group is almost ten beats below the average heart rate for the low fit group. Furthermore, the fit group was able to

complete the run in a shorter time (643 sec versus 706 sec) and with a lower average heart rate. This is consistent with expected fitness levels determined by the cycle ergometry test. Another factor that is indicative of fitness is the ability of the heart to recover from strenuous activity. The faster the heart returns to a normal beat rate, the higher the fitness. Figure 2 shows the recovery heart rates of subjects after the maximal run. It can be seen that the group classified as fit by previous cycle ergometry scores returned to a normal heart rate more rapidly after the maximal effort than did the group classified as low fit. This shows that cycle ergometry based estimates of fitness correlate with recovery heart rates of a 1¼ mile run.

Maximal Run

Avg Heart Rate vs. Avg Time

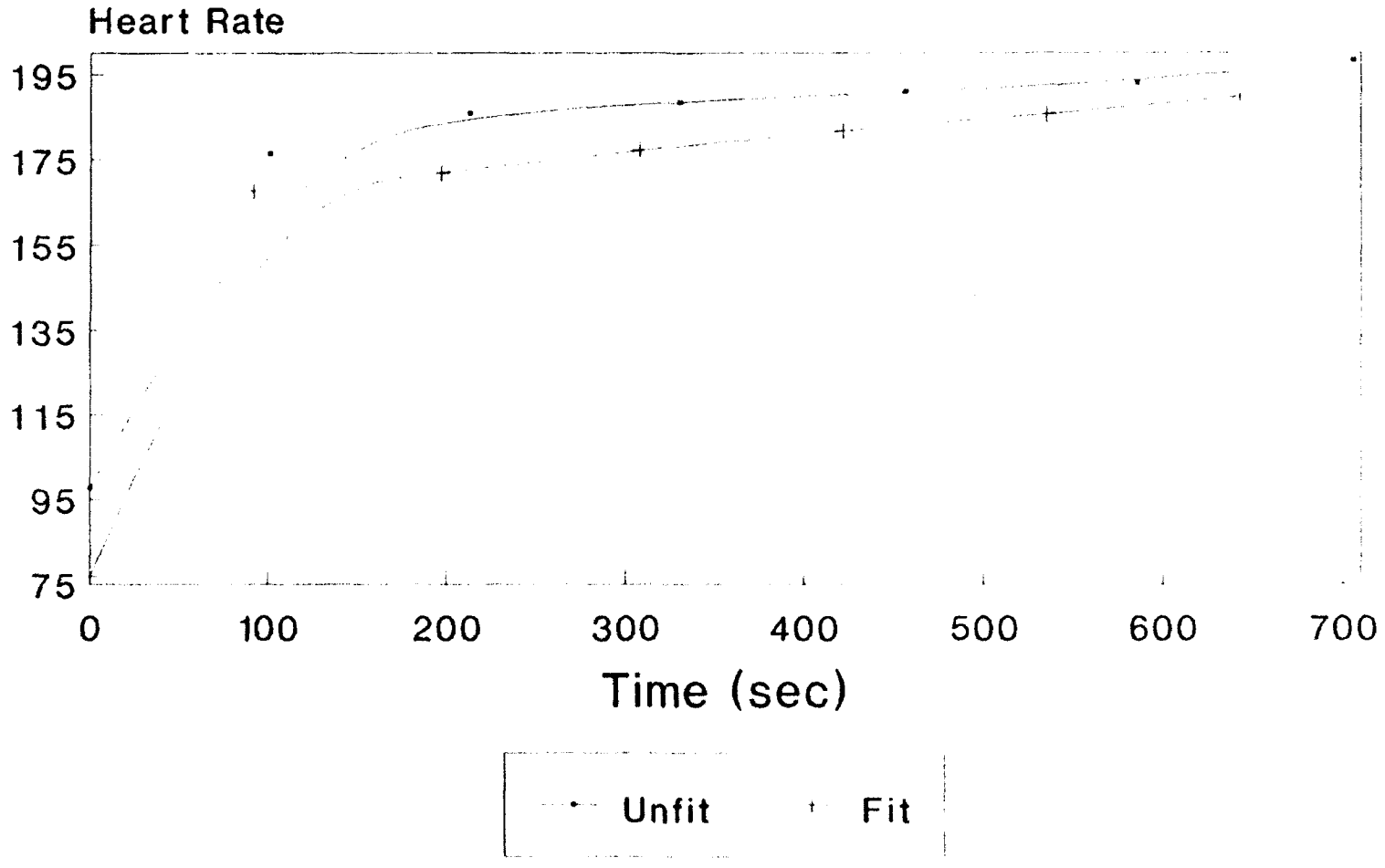

Figure 1

Recovery

Average Heart Rate vs. Time

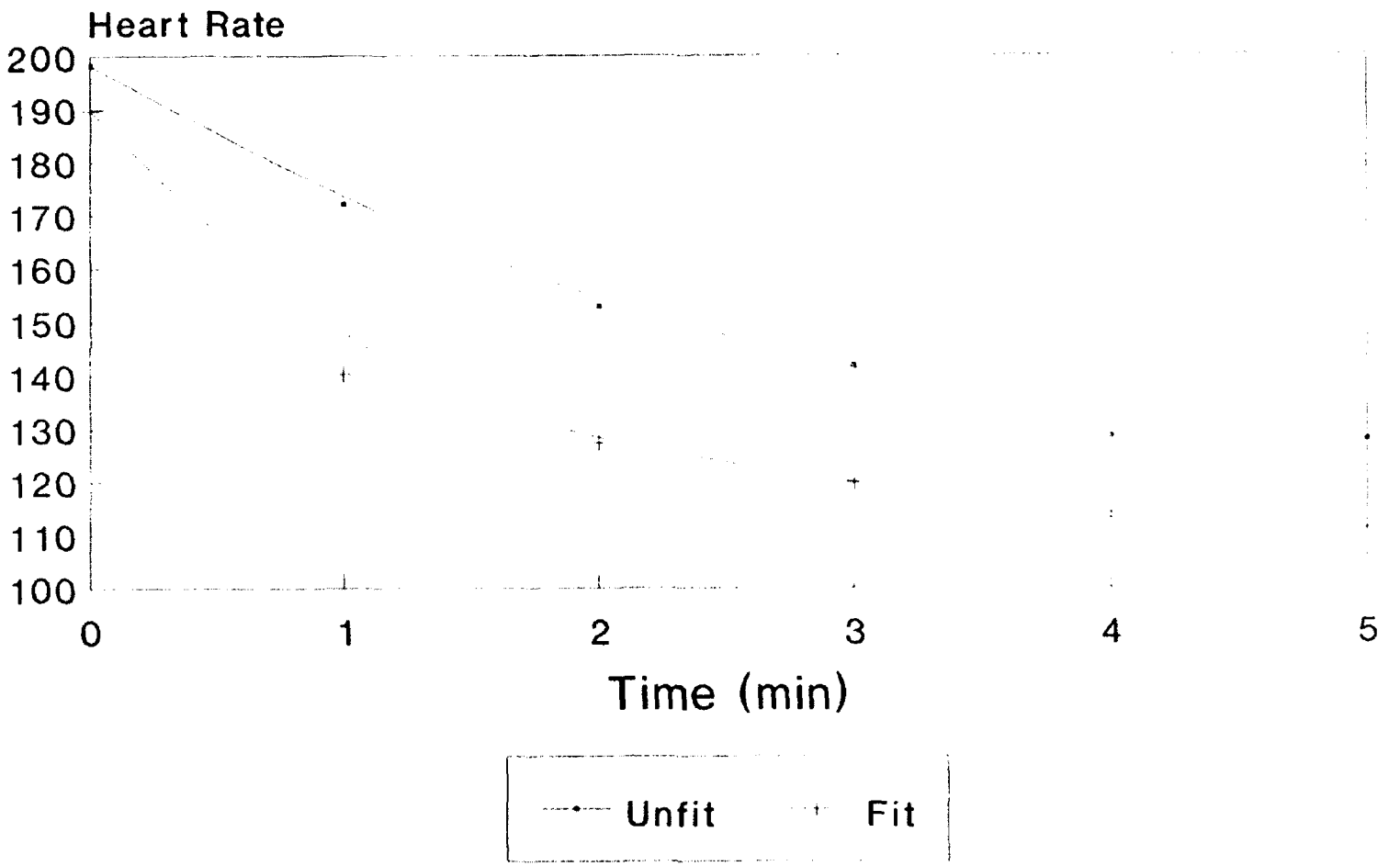

Figure 2

The difference in levels of fitness between the fit and low fit groups is also present in the average cycle ergometry scores for each group. Table 2 shows the average previous cycle ergometry scores and the average cycle ergometry scores obtained during the study. The previous cycle ergometry scores were taken from the most recent database available for Brooks personnel and were used to divide the subjects into the two groups. It should be noted that individuals in the low fit group have been engaged in a mandatory conditioning program since the original test. The increase in their scores and the decline in the fit group may in part be explained by the conditioning program followed since November 1991.

Table 2: Cycle Ergometry Scores

FITNESS GROUP*	AVERAGE AGE	AVERAGE PREVIOUS ERGOMETRY SCORE	AVERAGE STUDY ERGOMETRY SCORE
Low fit	24.5	32.67 ml O_2/(kg*min)	41.43 ml O_2/(kg*min)
Fit	23.25	57.15 ml O_2/(kg*min)	49.13 ml O_2/(kg*min)

* As classified by the cycle ergometry estimate of $VO_{2\ max}$.

The same difference between the groups classified as fit and unfit can also be seen in the submaximal run results. The completion times for the runs for each group can be seen in Table 3.

Table 3: Run Times

Fitness Group*	Maximal Run Time	Submaximal Run Time
Low fit	11 min 46 sec (706 sec)	14 min 46 sec (886 sec)
Fit	10 min 43 sec (643 sec)	13 min 18 sec (798 sec)

* As classified by the cycle ergometry estimate of $VO_{2\ max}$.

Table 3 shows that the group classified by cycle ergometry as "fit" was able to complete both the maximal and the submaximal runs faster than the "unfit" group. On the maximal run, the time needed to complete the run was over a minute faster for the fit group. On the submaximal run, the run time of the fit group was almost 1½ minutes better. This suggests that motivation may serve low fit groups better when they are asked to perform a maximal effort, as in the case of the Air Force's old fitness test. When heart rate was limited to 85% of the predicted maximum heart rate during the submaximal run, run times for the low fit group increased. This may indicate that submaximal testing is a better discriminator of fitness level. Motivation significantly influences performance during the maximal run. The submaximal run controls the influences of motivation by forcing runners to maintain a certain heart rate and by not allowing them to push themselves beyond that level. The factor of motivation is also controlled during the submaximal cycle ergometry test because subjects must pedal at a certain rate and are not allowed to overexert themselves in striving for a better score.

The average $VO_{2\ max}$ for each group was predicted from the data recorded from the submaximal runs using the procedure described earlier. Table 4 shows the predicted values for $VO_{2\ max}$ for both fitness groups based on the cycle ergometry test and the submaximal run. Although the predicted $VO_{2\ max}$ from the submaximal run is 12-14% lower than the cycle ergometry scores, the percentage differences between the scores of the two groups do not differ dramatically.

Table 4: Predicted $VO_{2\ max}$

Fitness Group*	Predicted $VO_{2\ max}$ - Cycle Ergometry (ml O_2/(kg*min))	Predicted $VO_{2\ max}$ - Submaximal Run (ml O_2/(kg*min))
Low fit	41.43	35.5
Fit	49.13	43.0
Percentage (Fit Higher Than Low fit)	18.6%	21.1%

* As classified by the previous cycle ergometry estimate of $VO_{2\ max}$.

This similarity in $VO_{2\ max}$ between the cycle ergometry test scores and the submaximal run scores is not surprising. Both are submaximal tests. The submaximal run appears to be a better indicator of fitness than the maximal run because of the reduction of the influence of motivation. Therefore, cycle ergometry may be better than the maximal run not only because of safety, but also because it decreases the effect motivation can have on estimating fitness by a maximal test.

Table 4 suggests that cycle ergometry may overestimate $VO_{2\ max}$ compared to the run based estimates. However, environmental conditions (heat and wind), the deviation of the test, and other factors may have lowered these estimates. One advantage of cycle ergometry is that environmental factors can be controlled. In any case, the relativity of the values were maintained for both the fit and low fit groups. The cycle ergometry test shows the scores of the fit group of subjects to be 18.6% higher than those of the low fit group. The submaximal run shows the scores of the fit group of subjects to be 21.1% higher than those of the unfit group. All the values obtained, though, are relative. The goal of this study was to determine whether cycle ergometry

classifications as fit and low fit correlate with expectations of performance on a 1½ mile run.

Conclusion

This study shows that the cycle ergometry test which will be implemented throughout the Air Force this October will provide a valid comparison of fitness between individuals. The results are reliable as an indicator of true fitness. The results may even be more reliable than the results of the maximal run because the cycle ergometry test controls the motivational factors. The cycle ergometry test is also safer than the run test because it is submaximal, producing less stress on the body, and is in a climate-controlled environment, reducing the possibility of heat stress and other related complications. Therefore, this study provides strong evidence that the cycle ergometry test to be used by the Air Force in the assessment of the fitness of its personnel is a valid fitness test.

Notes

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11. COL John R. Sharp, USAF MC, "The New Air Force Fitness Test: A Field Trial Assessing Effectiveness and Safety," Military Medicine 156 (1991): 181.

12. Bo Fernhall, PhD and Wendy Kohrt, PhD, "The Effect of Training Specificity on Maximal and Submaximal Physiological Responses to Treadmill and Cycle Ergometry," The Journal of Sports Medicine and Physical Fitness 30 (1990): 268.

13. Fernhall 273.

14. Cooper 203.

15. Sharp 184.

16. I. Astrand 55.

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THE ANALYSIS OF INORGANIC SUBSTANCES FOUND IN WATER

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Final Report for:
Summer Research Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
Brooks Air Force Base, San Antonio, TX

August 1992

THE ANALYSIS OF INORGANIC SUBSTANCES FOUND IN WATER

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Abstract

This summer as a participant in the HSAP summer research program for highschool students, many different areas of an analytical laboratory were exposed. The everyday function of the lab and the many tests performed daily were presented and explained in an efficient manner. As an apprentice, real laboratory experience was gained by "hands on" participation with the facilities and equipment found in the lab. While running different tests, safety was stressed so caution was taken. At all times a lab jacket was worn and on several occasions safety gloves were worn also. The importance of being exact, and precise in sample measurements and calculations was emphasized so that accurate results could be obtained. Once the results were found, they were distributed back to the field where they originally came from. The origins of the samples came from all over the United States and the world.

THE ANALYSIS OF INORGANIC SUBSTANCES FOUND IN WATER

Suzanne G. Weidner

In the Inorganic Analysis section of the Analytical Services Division at Brooks Air Force Base, water is tested for inorganic elements excluding metals from all over the world. Specific tests such as Turbidity, Chemical Oxygen Demand, Specific Conductance, and testing water for cyanides, phenols, phosphates, and chlorides were all conducted in the lab.

When samples are received at the lab, they go to Sample Control and are numbered and logged into the computer. Worksheets are generated and brought to the lab so that the results from the samples may be recorded. When the samples are waiting to be analyzed, they are kept in the freezer. Once ready, the samples are brought out and accounted for by the scientist. Afterwhich, the scientist can begin testing at anytime.

Before running each test, an explanation of the test was given by my mentor. He explained the method, how it was performed, and what equipment was to be used. Helpful hints were given so that problems could be avoided and accurate reliable results could be obtained.

TESTING

Conductance is a numerical expression which represents the ability of an aqueas solution to carry an electrical

current. This ability depends upon ions present in the water, their valence, mobility, total and relative concentrations, and the temperature at which the measurement is taken. The Specific Conductivity test is run on a Conductance-Resistance meter.

The Turbidity test is run on a Ratio Turbidimeter. This method compares the intensity of light scattered by the sample with the intensity of light scattered by that of a standard. When the intensity of scattered light is high, the turbidity is high also. Readings are read in Nephelometric Turbidity Units. When performing turbidity, the sample is shook continually for about one minute, the sample is then poured into a vial. The vial is put into the Turbidimeter for one minute and then read in NTU's.

Chemical Oxygen Demand or (COD) determines the quantity of oxygen required to oxidize the organic matter in a water sample. This is done by pipeting 2.5 mls. of sample in the ready to use ampules containing 1.5 mls. of digestion reagent and 3.5 mls. of catalyst. The ampules are placed in an oven for three hours and allowed to digest. After digestion, the ampules are read in a spectrophotometer at 600 nm.

Testing water for cyanides, phosphates, phenols, phosphates, and chlorides were all automated and performed on a Technicon Autoanalyzer. The Autoanalyzer consists of tubing by which the sample and reactants flow by continuous pumping. The sample is segmented by air pockets and the

reagents are mixed periodically with the sample in the coils. The sample is quantitated by passing a colored solution into a flow-through cuvette in a colorimeter and measuring the percent transmission.

After the samples have run through the Autoanalyzer, peak heights are calculated and graphed to determine how much of the substance is in the water. For instance, if cyanides, phosphates, and chlorides are found in water measurements are taken in mgs. per liter. However, if water contains phenols measurements are taken in micrograms per liter.

SAFETY

While at the lab, safety was stressed in order for the lab to be a safe working environment. Movies were shown on lab safety and instructions were given in fire safety. All apprentices participated in fire drills so that emergency exits could be found easily. A lab jacket was worn at all times during any type of testing. When working with strong acids, safety gloves were worn.

ROUTINE LAB PROCEDURES

During the week many of the tests are done at least once and sometimes more. Here is an example of a week and the tasks performed. On Monday, July 13th water was tested for turbidity, and Chemical Oxygen Demand was done. July 14th Phenols in water were run colormetrically on the Autoanalyzer. July 15th Peak heights were calculated from the phenols ran the previous day. Cyanides in water were run

colormetrically on the Autoanalyzer. July 16th Continued running cyanides in water from the previous day. Tested water for Specific Conductivity. July 17th Phosphates in water were run on the Autoanalyzer. Calculated peak heights from cyanides in water the previous day.

TESTING TIME

Each test takes a certain amount of time to perform. For example, when water containing phenols and phosphates are tested on the Autoanalyzer, twenty samples can be run an hour. Usually, anywhere from forty to sixty samples are run each time phenols and phosphates in water are tested. When water is tested for cyanides using the Autoanalyzer fifteen samples can be run during an hour. Around forty to sixty samples are run each time. When water is tested for chlorides, thirty samples can be run during an hour. Forty to sixty samples are usually run at that time also.

When testing water for Specific Conductivity, correct readings usually show up five to ten seconds after the wand is submerged into the sample. Approximately twenty to twenty-five samples a week require testing for Specific Conductivity.

When a water sample is tested for turbidity, the sample is put into the Turbidimeter and in about one minute you will have a reading. Anywhere from ten to fifteen samples are tested weekly for turbidity.

MINIMUM AUDIBLE ANGLE STUDY

Amy L. Zimmerman

Final Report for:
Summer Research Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
Wright Patterson Air Force Base, Dayton, Ohio

August 1992

MINIMUM AUDIBLE ANGLE STUDY

Amy L. Zimmerman

Abstract

The minimum audible angle technique is used to determine how well human listeners can localize sounds. In this study, subjects listened to two tones and determined if the second tone was to the right or the left in relationship to the first tone. The tones were presented from 1 to 15 degrees in either direction(right or left) from the first tone that was presented at a standard angle. The standard angle was set by moving clockwise around the head(0,30,60,90 degrees). Experimental results indicate that the minimum audible angle at 0 degrees(ie. directly in front of the person) is 5 degrees in either direction while at 90 degrees the MAA was 14.5 degrees. We concluded that the best localization occurs in front of the person.

MINIMUM AUDIBLE ANGLE STUDY

Amy L. Zimmerman

Introduction

The minimum audible angle (MAA) technique is often used to study how human listeners localize sound. The MAA paradigm which is a model or experimental design was developed by Mills in 1958. The paradigm is used to measure the accuracy with which human listener's can localize sound. In the past, people of different ages and people with hearing problems have been used as subjects.

The MAA paradigm involves three sound source locations. A center or standard location is chosen at some angle with respect to the forward position. This can be seen in figure 1. The second and third sound locations are to the right and the left in relationship to the center. Sound is presented to the listener at two locations. The first sound is presented from a standard position and the second is presented to either the right or the left of the first sound.

This paradigm has been used by William Hartmann and Brad Rakerd. They applied the MAA technique in different ways. Besides the paradigm described above, they also presented two tones, one to the right and one to the left separated by an angle that they refer to as A. For their study they used a special set

of three speakers they call the "hydra". They performed an experiment to prove the MAA technique to be inaccurate. They hoped to lessen the difficulty of the interpretation in terms of statistical analysis.

MINIMUM AUDIBLE ANGLE FACILITY

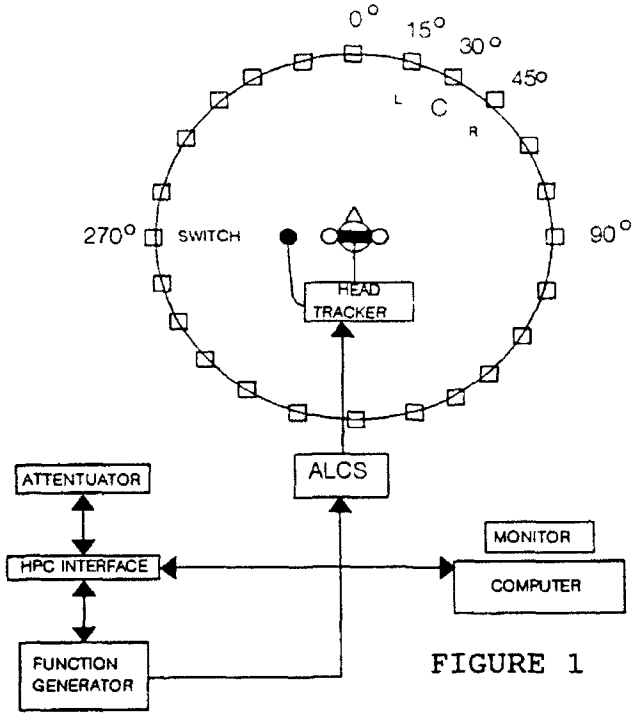

FIGURE 1

Our study is being conducted to find the minimum audible angle at which a person can localize using 3-D sound over headphones. The Air Force will use the data to develope methods of helping pilots to perform their tasks in the cock-pit. They hope to have an audio system in the cock-pit that can tell the pilot where enemy planes are by the sound and not only the radar scope.

Methodology

For our experiment, we wanted to reproduce parts of Hartmann and Rakerd's experiment. We changed a few things with the set-up, but tried to keep it as similar as possible. We did not use the "hydra", but instead used headphones. We did not try all the experiments that they tried. We also hope to expand on their experiment. We plan to try some new things such as different noises.

To begin the experiment we had to locate equipment and set it up. The equipment then had to be calibrated to specific measurements. The sound stimulas must be free of noise when played through the headphones to get good responses and data from the subjects. If the tone is turned on or off too fast, the listener will interpret a click before or after the tone although in actuality they did not hear anything. There is a specific slope at which noise can be turned on and off without getting clicks.

The computer program used to run the experiment and the pre-planning stages of the project had been completed before I began my summer. The program was written in C++ which is basically C programming with more structures and options. Since I arrived at the beginning of the summer, I have learned much about C programming and have also had the opportunity to do some programming for another project. I found the code in the MAA

program fairly easy to follow but made no attempt to do any modifying.

The sound equipment was set up in a large reverberation chamber that was chosen for the experiment. A programmable attenuator was used for removing extra noise at the beginning and at the ending of the tones. An attenuator is a device that reduces the amplitude of an alternating-current wave without introducing appreciable distortion. A government built, HPC interface allows the computer to "talk" or commmunicate with the attenuator. Tones were produced by a Hewlett Packard 3300 function generator. The tones were then sent through the Auditory Localization Cue Synthesizer (ALCS). This instrument processes the sounds so that it sounds like the tones are in different locations relative to the listener. To monitor exactly where the head is, a 3-space Pohlhemus headtracker is used. It has a switch to zero it and is portable. The purpose of the headtracker is to allow for some slight head movement which was allowed for in Hartman and Rakerd's experiment. (This equipment can be seen in figure 1,a top view; and in figure 2, a side view.)

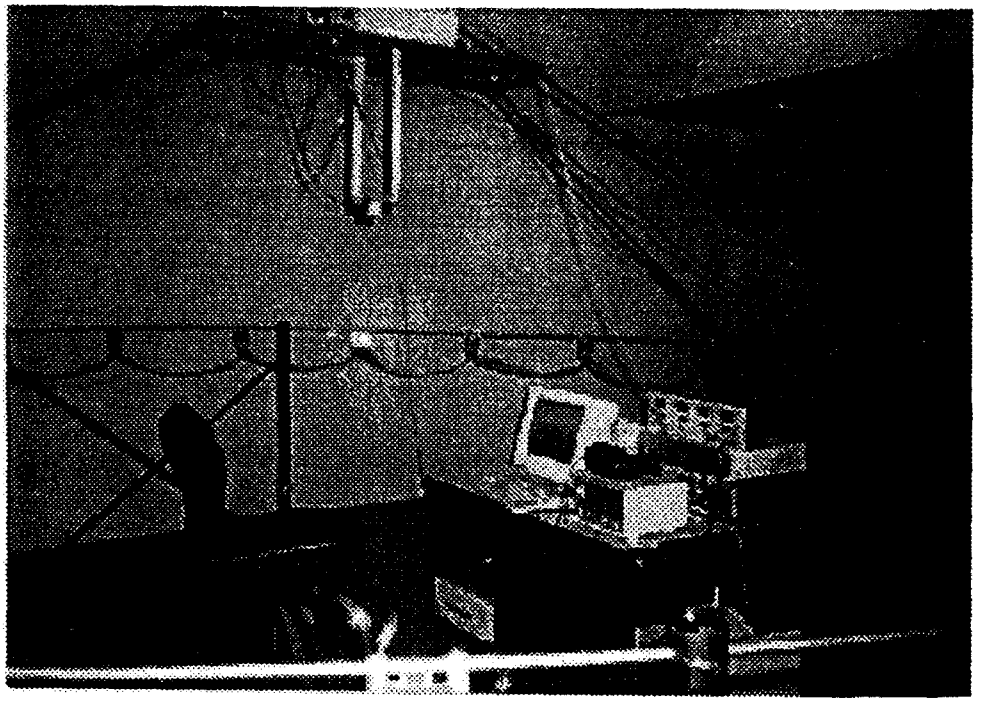

FIGURE 2 - VIEW OF SET-UP

After the equipment was set up, the subjects were brought in for a test run. The subjects were chosen randomly based on their availability. They were given instructions about the task. The subjects looked at a flourescent orange flag which became the 0 degree mark for the experiment. At which time the subject put on the headset and was given a hand-held mouse to register his/her responses. The subject then began his/her first block of 124 sets of 2 tones each. At the end of each block, the subject was given data in the form shown in figure 1.

The subject's name, date, and time were recorded identify each subject's trial.

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Jane Doe
30 JUN 8:20
-543210987654321012345678901234 5
0  11111111111011010111111111111111
30 10111101101110101111111011111011
60 11100100010100100101011111111111
90 00101001010101001001011011010 10
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FIGURE 3 - SAMPLE DATA

In figure one above, the far left column indicates the standard angle and the top row of numbers indicates how far the tones were apart. Ones indicate correctness and zeros indicate errors in the subject's responses. Each subject ran four blocks of the test which took approximately 45 minutes including the small breaks in between blocks. After the subject completed the task, he/she was given a piece of paper with this question on it to check that the subject had the correct method for completing the task:

> "For the experiment that you have performed, the appropriate response was left mouse button if the second tone was to the left of the first. The appropriate response was right mouse button if the second tone was to the right of the first. Is this the way you performed the experiment?"

If the subject did the task correctly, his/her data was recorded and saved in a file with other subjects' trials. We used 7 subjects including myself. Each person completed a total of 10 blocks of tones in order to check for a learning curve and also have more complete data. In checking for learning curves we looked for improvement after each block. Once there is no more improvement, we then consider the task learned and the data should be about the same for that subjects future trials.

After discovering some problems with confusion as to where the tones were, we tried other experiments to try to avoid the problem. So, I ran the experiment under a different set of instructions with subjects who had never done the previous task. Instead of telling the subjects that the tone was to the right or left, I told them to consider the second tone to be clockwise or counter-clockwise from the first tone. But this method did not prove to be beneficial because the subjects assumed I really meant right/left. I ran the experiment with my head in motion the entire time so that the tones would not be linear. This did not effect the results very much either. Just to make sure that anyone could at least get 50% correct, I did a totally random trial not even listening to the tones and got almost 50% correct. This shows that when the subjects are missing more than 50% they are probably not doing the task correctly or the equipment is not working properly.

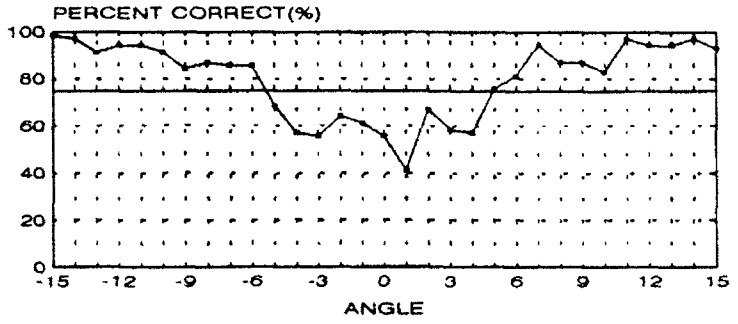
Results

The results were tabulated as shown in figure 3. All the trials of all the subjects went into a file and from that file the numbers were averaged together. I then graphed the analyzed numbers on line graphs. We chose the cut-off for the study to be at the 75% range. The first four graghs show the results of seventy points of data at the different angles as displayed on each graph. The X-axis represents the left and right angle degree changes and the Y-axis represents the percent correct. The final graph is a comparison of the minimum audible angles at the different standard angles(X-axis).

Graphs of Results

MINIMUM AUDIBLE ANGLE

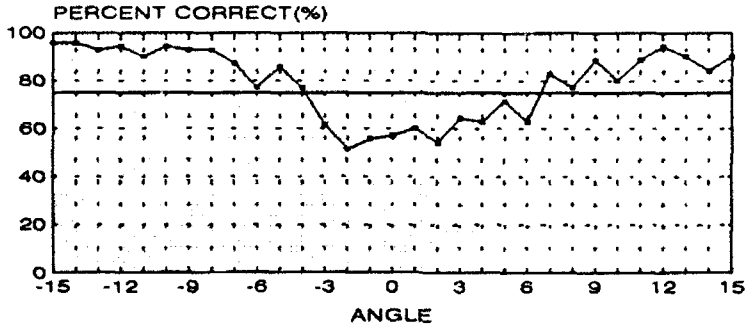
TARGET AT 0



7 SUBJECTS, 10 BLOCKS OF DATA PER SUBJECT

MINIMUM AUDIBLE ANGLE

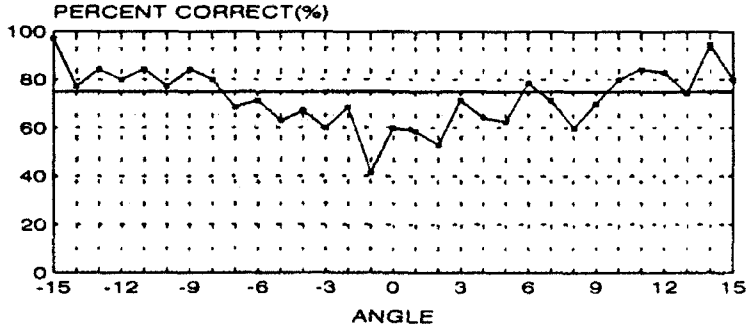
TARGET AT 30



7 SUBJECTS, 10 BLOCKS OF DATA PER SUBJECT

MINIMUM AUDIBLE ANGLE

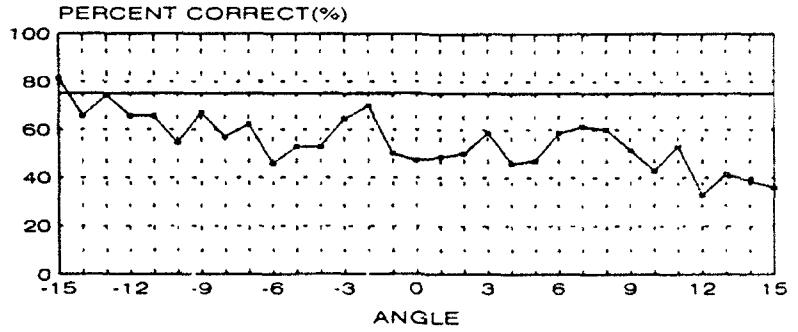
TARGET AT 60



7 SUBJECTS, 10 BLOCKS OF DATA PER SUBJECT

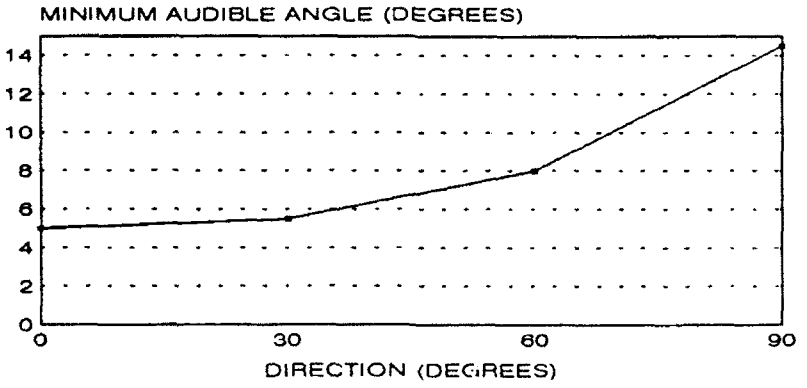
MINIMUM AUDIBLE ANGLE

TARGET AT 90



7 SUBJECTS, 10 BLOCKS OF DATA PER SUBJECT

MINIMUM AUDIBLE ANGLE VS. DIRECTION



7 SUBJECTS, 10 BLOCKS OF DATA PER SUBJECT

Conclusion

From the results, I conclude that humans localize better at zero degrees because the MAA is the smallest there. The data shows that at approproximately 5 degrees, to the right or the left, of the center is the minimum audible angle with which our subjects could localize at the zero degree position. At 90 degrees, tones are heard in one ear and it is hard to distinguish if it is in front or behind the listener. It is more difficult to perceive because the brain is receiving less data.

Recommendations

For further study, the experiment is going to be run with different stimuli. Other experimenters in the Biocommunications laboratory on base are going to try speech and also broadband noise instead of the pure tones that we used in this study. Future experiments will include an incentive program so that subjects will be motivated to pay very close attention to the task and not just on finishing it so that they can get another break. The incentive program will allow for everyone to earn some monetary compensation. Even if the subject is not the best localizer, he/she will still try his/her best to earn a bonus. The results of each session will be posted to make the experiment fun and competitive for the subjects.

References

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minimum audible angle - A decision theory"; J.Accoust.Soc.Am. 85, May 1989.

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