Report No. 65-31
July 15, 1965

BIOTECHNOLOGY LABORATORY

PROGRESS REPORT

Period of March 15 to July 15, 1965

UPPER EXTREMITY PROSTHETICS RESEARCH
(Contract V1005p-9779 with U.S. Veterans Administration)

HUMAN TRACKING
(Contract N123(60530)32857A with
U.S. Naval Ordnance Test Station, China Lake, California

SENSORY MOTOR CONTROL
(Grant VRA RD-1201M-64)

MYOELECTRIC CONTROL

(Contract No. AF-33(615)-1969 with U.S. AIR FORCE)

Project Leader: John Lyman
Professor of Engineering and Psychology
Head, Biotechnology Laboratory

Department of Engineering
University of California
Los Angeles, California

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Engineering Dept. Report

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DEPARTMENT OF ENGINEERING
University of California
Los Angeles

BIOTECHNOLOGY LABORATORY STAFF

Professional Staff:

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Ibrahim, Abdul	B.S.
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Lucaccini, Luigi	M.A.
Lyman, John	Ph.D., Project Leader
Nachman, Bernard	M.S.
Nachshon, Aharon	B.S.
Rey, Paule	M.D. (foreign visitor October 1964 to October 1965)
Smith, Russell	M.A.
Weltman, Gershon	Ph.D., Associate Project Leader Myoelectric Control
Williams, John	M. Eng. Sci.

Professional Consultants:

Bechtol, Charles O.	M.D.
Brooks, Milo	M.D.
Mazet, Richard	M.D.
Perry, Jacquelin	M.D. (Rancho Los Amigos Hospital)

Visitor:

Arezina, Petar	M.D. (Belgrade, Yugoslavia on a three months HEW grant)

Technical Aides:

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EXPERIMENTAL SUBJECTS

Barnai, Robert
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Heiner, Victor
Kernek, Al
Ketron, Roger
Kleinbrodt, Michael
Miller, Clark
Shert, Marie
Shiell, Walter
Singh, Bawa, J.B.
Snow, Richard
Sonder, Tami
Walker, Ken
Young, Don

FOREWARD

The research described in the Biotechnology Laboratory Progress Report was carried out under the technical direction of John Lyman and is part of the continuing programs in Upper Extremity Prosthetics Research, Human Tracking, Sensory-Motor Control, and Myoelectric Control Research.

The Biotechnology Laboratory is part of the Department of Engineering of the University of California, Los Angeles. L.M.K. Boelter is Dean of the College of Engineering and Phillip F. O'Brien acts as his representative for research activities.

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I. UPPER EXTREMITY PROSTHETICS RESEARCH

Sponsor: U.S. Veterans Administration

1.0 Needs Analysis for Development of Externally-Powered Prostheses Design Specifications

1.1 Objective

1.1.1 To re-evaluate currently used design specifications of existing convrntional prosthesis subsystems as, for example, terminal devices, and elbow lift and lock mechanisms.

1.1.2 To compare these design specifications with available criteria for externally-powered prosthesis subsystems, and the specific design goals in terms of functional regain.

1.1.3 To integrate the findings of the needs analysis into design criteria quantification of the complete externally-powered prosthetic system.

1.2 Current Status

Inactive

2.0 Analysis of Existing Externally-Powered Prostheses and Development of Advanced Design Specifications

2.1 Objective

To make an engineering and performance evaluation of existing devices to asses their capabilities and limitations and derive specifications for further development.

2.2 Current Status of Experimental Investigations of the Northwestern Attitudinally Controlled Elbow

The manuscript is ready for editing to conform to current publication instructions.

2.3 Current Status of Experimental Investigations of the AIPR Pneumatic Arm

Data analysis of the results of the investigation of this prosthesis for the unilateral AE amputee pilot wearer has been completed. A first draft of the results of the evaluation is nearing completion and should be submitted for editing shortly.

2.4 It is expected that the final manuscript for the AIPR evaluation study will be submitted to the contracting agency within the coming quarter.

3.0 Evaluation of the Utility of Minor Surgical Alterations for Developing Body Control Sites for Externally Powered Prosthesis

3.1 Objective

To develop surgical methods requiring only "office procedures" that will modify muscle control sites in such a way that voluntary control will become more reliable and harnessing to a transducer will be facilitated.

3.2 Current Status

3.2.1 A small muscle hernia was created surgically in the pectoralis muscle of a volunteer amputee and post operative measurements of output control have been made. Initial data seem to show a considerable improvement of the mechanical output in comparison to the preoperative measurements.

3.2.2 Dr. Bechtol performed experimental surgery on the back muscles of a rabbit, enclosing specially shaped plastic transducer models into split skin grafts and inserting them into the belly of the muscle.

Dr. Bechtol

The first experiment was unsuccessfull, since the muscle expelled the skin lined transducer models and pushed them into a subcutaneous location.

Plans have been made for a second surgery incorporating changes in size and shape of the transducer models and modifications of the surgical procedure

4.0 Exploration of Harnessing Techniques for Control Site Harnessing

4.1 Objective

To assess various methods of harnessing a particular type of mechano-electrical transducer to selected control sites in terms of: 1) optimum transducer output, 2) reliability of function, 3) ease of application, 4) wearing comfort and 5) toxicity of materials in contact with the skin.

4.2 Current Status

4.2.1 Experimental investigations are in progress exploring the capabilities of several transducers developed for patients with cineplasty tunnels. Three amputees, two with biceps cineplasties and one with a pectoral cineplasty are currently being tested. Initial results look very promising in terms of control sensitivity and ease of harnessing.

The studies will serve as a basis for possible experimental surgery on a volunteer amputee for creating miniature cineplasty tunnels for control sites.

4.2.2 Experiences obtained over the past several months with several experimental transducers have been summarized. This material will be published as a technical note.

4.2.3 A survey of the available information on adhesives is in progress.

II. RESEARCH ON SENSORY MOTOR CONTROL

SPONSOR: OFFICE OF VOCATIONAL REHABILITATION

(Federal Rehabilitation Administration)

1.0 Objective

To conduct basic and applied research on arm prostheses sensory-motor control problems and undertake analysis of prosthesis-amputee systems.

2.0 Current status of experimental investigations of functional muscle isolation

Experimental investigations were continued during the past four months, data reduction is in progress. Manuscripts for publication will be prepared.

3.0 Development of an external logic system

3.1 Objective

To develop a system that will provide a maximum number of independent prosthetic functions with a minimum number of body control sites.

3.2 Current status

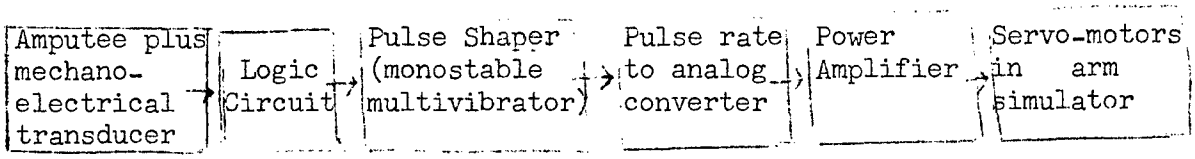
A control loop is being developed between body control sites and an arm prosthesis simulator capable of three-dimensional motions. The different time variable functions of the transducer output are being utilized as control parameters.

A control logic circuit using the rise time of the transducer's output will provide the amputee with a tristate control from each available site: 1) positive, 2) zero, 3) negative. The system is capable of providing: 1) selection of motion direction and 2) speed and position control.

Motion direction is selected as a function of the rising rate of the ramp output ($\frac{da}{dt}$). Fast rates will result in one direction and slow rates in the opposite. Speed control will be a function of pulse frequency.

An electronic system connecting and translating the logics outputs into control power is designed and is in the last stages of construction.

A block diagram of the system is presented below:



A pilot experiment indicated that subjects are capable to operate the logic using an abdominal photo-cell transducer, chest expansion strain gage and a pectoralis strain gage. Three servomotors simulating the joints in the arm simulator will be controlled with this technique. Arm position must be sensed visually.

4.0 Current Status of Experimental Investigations of the Heidelberg Pneumatic Arm

During the past quarter the evaluation report was revised according to editing instructions. The final draft was put into manuscript form conforming to contract specifications. It was submitted in May to the contracting agency and should appear soon as a Veterans Administration report.

5.0 Performance evaluation of the Belgrade (Yugoslavia) Electronic Hand

5.1 Current Status

The project was inactive

III. RESEARCH ON THE PERFORMANCE OF HUMAN OPERATORS OF TRACKING SYSTEMS

Project Administered by U.S. NOTS
China Lake, California

Sponsors: U.S. Naval Ordinance Test Station, China Lake, California
Naval Missile Center, Point Mugu, California
Department of the Army, White Sands Missile Range, New Mexico
Patrick Air Force Base, Florida

1.0 Performance Evaluation of Variables of the Optical System on the NOTS Tracking Simulator

1.1 Objective

Systematic evaluation of variables of the optical system on target acquisition and tracking accuracy. Design specifications for optimum performance shall be derived. Handbooks or tables will be ultimately developed to aid tracking system designers.

1.2 Experimental Investigations on the NOTS-UCLA Tracking Simulator

1.2.1 New tracking laboratory: The new tracking laboratory was completed on the first of June. Due to University constraints the completion of the laboratory was delayed several months beyond our initial expectations. The simulator and all associated equipment except the new X-Y plotter and target function generator have subsequently become operational. It is expected that these devices will soon be functional.

1.2.2. Technical reports: Three technical reports of past research are being readied for publication. Summaries of these reports were presented in previous progress

reports. Additionally, two tracking articles have been prepared for submission to appropriate journals. Upon completion of the new function generator and mirror-drive system a technical note will be prepared describing the devices.

1.2.3 Experimental plans: Experimental designs are developed for investigating problems of acquisition, re-acquisition, operator predictive abilities in tracking known and unknown trajectories and various optical parameters including switching between two lens systems. Plans are also being formulated for follow-up experiments which will tentatively be designed to determine the effects of stress, e.g., heat and fatigue, and trajectory characteristics on tracking performance.

1.3 Final contractual commitment: Handbook Data

The ultimate objective of the tracking research program at the UCLA laboratory has always been the development of handbook data. Thus the final report under the present contract will detail pertinent data from all past research and include relevant data from other laboratories which are believed generalizable to heavy inertia systems. This report will conform as closely as possible to engineering type handbooks. It will contain data relating to 1) human sensorimotor and predictive capabilities, 2) optical system parameters including magnification, field of view, lens switching and display modes, 3) multiple sensory cues, i.e., usual and proprioceptive information, 4) aiding, 5) controller configurations, 6) trajectory characteristics, i.e., target velocity, acceleration and irregularity, 7) learning and

transfer of training, (8) problems Of acquisition and re-acquisition, 9) effects of physiological and environmental stress on performance and etc. Attention will be focused on presenting optimal design data and indicating performance trends where designs deviate from the optimal. An attempt will also be made to include data regarding variables such as skill and motivation as they relate to psychomotor tasks. It is hoped that this report will aid as a basic starting point for engineers concerned with the design of human tracking systems.

IV. RESEARCH ON MYOELECTRIC CONTROL SYSTEMS

Sponsor: U.S. Air Force; ASD-Bionics Branch

1.0 Objective

To experimentally define the variables that determine the performance of a human operator in multidimensional myoelectric control systems.

2.0 Current Status of Research

2.1 All experimental instrumentation has been designed, modified, updated and checked out for reliable operation. Experience accumulated in a series of pilot experiments led to the finalization of the major experimental program and the statistical design for the individual experiments.

The following laboratory investigations are in progress:

1) Spectral analysis of EMG recordings obtained from the gastrocnemius and anterior tibialis muscles.

2) Evaluation of three techniques for ECG cancellation occurring as noise in the EMG signal: a) frequency separation, b) simple cancellation, c) blocking. Experimental mapping of the ECG occurring in the EMG a large number of muscle groups is in progress.

3) A unidimensional tracking experiment has been designed to investigate the following variables:

Three control modes providing:

a) binary control

b) graduated, i.e., rate control

c) combination of binary and rate control.

Three display speeds:

a) slow

b) medium

c) fast

Three control site combinations:

a) agonist-antagonist: anterior and posterior deltoid

b) two unrelated muscles on the same side: anterior deltoid and pectoralis

c) two related muscles on opposite sides: right and left pectoralis

Three tasks:

a) simple alternation between limits of varying distances

b) step responses

c) sine wave tracking

2.2 A literature survey has been submitted to the principal investigator but will need extensive editing and revisions to make it suitable for publication.

2.3 Multidimensional Control Studies

The Space Labs powered arm brace has been extensively modified for utilization in the planned multidimensional control studies.

PROFESSIONAL ACTIVITIES OF STAFF MEMBERS

April 6-10, 1965

The Warrenton Conference on the Control of External Power in Upper-Extremity Rehabilitation. Dr. John Lyman was Chairman of the Conference. Dr. Hilde Groth was Chairman of the Panel on Sensory Feedback. Dr. Paule Rey presented a paper on Matching Transducers to Body Control Sites.

June 13-19, 1965

Dr. Hilde Groth attended the course on Child Prosthetics at the University Conference Center at Lake Arrowhead.

June 11-21, 1965

Dr. Paule Rey attended the Annual Meeting of the Western Psychological Association in Honolulu, Hawaii and presented a paper entitled "An Evaluation of Visual Codes for Quantitative Velocity Information. (coauthor: Hilde Groth)

Dr. John Lyman is currently on sabbatical leave in Delft, Holland. His professional activities will be reported after his return.

July 7-15, 1965

San Francisco, Oakland, Menlo Park, Palo Alto. Dr. Hilde Groth attended Conferences with project leaders of research contracts related to current contracts in Biotechnology. Conference with the VRA contract monitor.

PUBLICATIONS

L. F. Lucaccini, R. Wisshaupt, Hilde Groth, and J. Lyman

"Evaluation of the Heidelberg Pneumatic Prosthesis", Biotechnology Laboratory Technical Report No. 30, UCLA Engineering Department Report No. 65-19, December 1963.

Abstract:

An evaluation was conducted on an upper-extremity prosthesis developed at the University of Heidelberg. The prosthesis provides bi-directional movement around three axes (elbow, wrist, and hand) and is powered from a portable CO_2 source. Engineering tests measured speed of movement for each component, forces available from each component, mechanical time lags of each component, characteristics of the control system and brief descriptions of the operation of the various units of the prosthesis. Performance tests on two amputees (unilateral AE and unilateral forequarter) provided information regarding range of motion, speed in initiating functions, precision of control of the functions of the prosthesis and ability to perform a series of standardized tasks under normal and stressing circumstances.

R. L. Smith, L. F. Lucaccini, Hilde Groth and J. Lyman

"Effects of Anticipatory Alerting Signals and a Compatible Secondary Task on Vigilance Performance", Journal of Applied Psychology, 1966, in press.

Abstract:

An experiment was performed to test the effectiveness of anticipatory alerting signals on a complex vigilance task. Twenty-four male and 24 female undergraduates served on the one hour task. In one condition subjects were alerted to possible targets by a buzzer with one

second foreperiod. Between buzzes they worked on a series of problem-solving tasks (anagrams). A second condition was identical to the first except that subjects rested between buzzes. In a third (control) condition subjects continuously observed the display without benefit of alerting signals. Other variables of interest were display window size, sex of observer and type of target. It was found that:

a) in no condition was the "typical" vigilance decrement in evidence

b) alerted subjects not only performed better than controls, but improved their performance with time

c) no differences were found between males and females

d) alerted subjects with the secondary task rated the task as "interesting" and underestimated the duration of the experiment, while controls and alerted subjects without the secondary task rated the task as "boring" and estimated duration accurately.