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A SYNOPSIS OF THE UCLA BIOTECHNOLOGY LABORATORY
FUNCTIONAL EVALUATION OF
EXTERNALLY-POWERED ARM PROSTHESES

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FOREWORD

The research described in this note, A Synopsis of the UCLA Biotechnology Laboratory Functional Evaluation of Externally-Powered Arm Prostheses, by Hilde Groth, John Lyman and Peter Kaiser, is part of the continuing program in "Arm Prostheses Research."

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OBJECTIVE

Performance evaluations are made to determine for each possible simple prosthesis movement and for coordinated complex motions the following parameters:

1. Precision of motion
2. Speed of motion
3. Range of motion (when applicable)

Integration of data obtained from engineering analyses of the particular prosthetic system under consideration with performance data is directed toward an objective evaluation of prostheses control adequacy. The results of each investigation are then incorporated into a statement of recommendations for improving the specifications for control sites, control sequences and transducers.

METHOD

I. Analyses of isolated motions

Rationale: To quantitatively assess the detailed aspects of control adequacy.

A. Time required for each motion from control activation to required end position is determined for the following simple motions as applicable and coordinated movements consisting of two or more simple motions:

1. prehension of an object
2. releasing an object
3. wrist flexion
4. wrist extension
5. wrist rotation clockwise

6. wrist rotation counterclockwise
7. elbow flexion
8. elbow extension
9. shoulder abduction
10. shoulder adduction

Additional data are recorded as follows:

1. Types of inadvertent prosthesis activations
2. Frequency of such activations

B. Measurements of the precision of the required motion in pre-determined spatial locations are made for simple and complex movements. Since it can be assumed that given adequate time, the amputee can achieve 100% accuracy, the length of time necessary to attain the designated spatial location represents one index for control adequacy. The number of re-positionings necessary before successful completion of the movement serves as another measure of accuracy.

C. Measurements leading to the evaluation of the adequacy of the control mechanism for prehensile functions are obtained for three aspects of prehension:

1. prehension span reproduction
2. prehension force reproduction
3. thickness discrimination

II. Analyses of coordinated motions

Rationale: 1. To evaluate the control adequacy for the entire prosthesis, treating it as an integrated articulated unit capable of performing complex tasks.

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2. To assess the degree of independence an amputee can achieve for performing selected routine tasks of every day life.

A. Performance of standard manipulation tests of known validity and reliability requiring graded levels of motor skill for successful completion provide speed and accuracy data of good precision for the evaluation of coordinated movement capability.

An example of a useful test of this type is the Minnesota Rate of Manipulation Test.

B. It is recognized that one of the most important aspects of prosthetic replacement is to permit the amputee to achieve independence in the following areas:

1. Self-feeding
2. Personal hygiene (e.g. washing, toileting, etc.)
3. Self donning and doffing of the prosthesis
4. Coping with the general environment (e.g. opening doors, driving car, etc.)

An assessment of these functions is made by measuring performance of a series of "every-day tasks" standardized for laboratory testing. Less adequate quantitative performance measures are obtained from these tasks, but they have the advantage of motivating the amputee subjects. Although the tasks are of unknown reliability, they have sufficient face validity for inclusion in a testing procedure since they constitute a representative sample of an amputee's routine task requirements. The selected tasks are:

1. picking up, moving and releasing a briefcase
2. putting a hanger on a clothes tree
3. opening a door
4. manipulating a lid on a jar
5. sharpening a pencil
6. putting pencil in breast pocket
7. manipulating a fly zipper
8. answering a phone
9. soup ladling
10. drinking from a coffee cup

EVALUATION PROBLEMS

All comparisons are made "between" the conventional prosthesis regularly worn by the amputee and the various externally-powered devices. In every case, a correction is made for lags inherent in the mechanism in order to avoid confounding "equipment time lags" with "human time lags." The familiarity of the amputee with his own prosthesis in comparison to the test devices represents a problem which has to be noted but cannot be remedied. An equal amount of training time is devoted to each new test device prior to experimentation, but this, of course, does not guarantee an equal amount of skill acquisition at that time. Differences in control sites and mechanisms require various amounts of training to attain comparable skill levels, and at present no evaluation of the adequacy of initial training times is attempted.

Although every effort is made to collect objective quantitative data which can be treated by appropriate statistical methods, not all aspects of the overall problem are amenable to this approach.

Subjective responses volunteered by the amputee subjects are also recorded and serve to verify quantitative data as well as clear up discrepancies. The technique for accomplishing this is the "Critical Incident Interview" where emphasis is placed on actual experience that can be described in objective terms (e.g., "the coffee cup fell out of my hook"). All amputee subjects are carefully selected to avoid confounding of medical problems (e.g., pain due to neuromas) with prosthesis control adequacy.