Order Number 9000034

Translucency, body contact, and production complexity: Effects on the acquisition of American Sign Language signs by aphasic adults

Hughes-Wheatland, Roxanne, Ph.D.

City University of New York, 1989

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

A

Translucency, Body Contact, and Production Complexity: Effects on the Acquisition of American Sign Language Signs by Aphasic Adults

By

Roxanne Hughes-Wheatland

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy. The City University of New York.

1989

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirements for the degree of Doctor of Philosophy.

12/27/88
Date

Chair of Examining Committee

January 4, 1989
Date

Executive Officer

Dr. E. Perecman

Prof. Arlene Kraat

Dr. H. Shuckman

Dr. Louis Gerstman

Supervisory Committee

The City University of New York

Abstract

Translucency, Body Contact, and Production Complexity: Effects on the Acquisition of American Sign Language Signs by Aphasic Adults

by

Roxanne Hughes-Wheatland

Advisor: Professor James R. Tweedy

The present study examined how the three features translucency, body contact, and production complexity, influenced acquisition and recall of 24 American Sign Language (ASL) signs in eight aphasic (males = 5, females = 3) and six normal (males = 3, females = 3) adult subjects. All of the subjects were right handed.

Gestural and language pretests were administered to all of the aphasic subjects prior to sign training. All subjects were trained to produce the 24 ASL signs using the procedure of handshaping and physical guidance. Twelve signs were trained during each of two training sessions. Evaluations were administered immediately following training (initial tests), at the end of each training session (probe 1), and one week following training (probe 2).

Aphasics were shown to be impaired in the acquisition and recall of ASL signs on the initial tests and probe 1, however, in comparison to the normal controls, the aphasics' probe 2 recall performances were not significantly impaired. In terms of the three sign features examined, the results revealed that among aphasics production complexity was more important for sign acquisition, and translucency was more important for sign recall. Body contact, although an important feature for short-term sign recall by both subject groups, was also important for long-term recall among the normal controls. The results are best interpreted as supporting an apraxia based neuropsychological theory of gesture production impairment.

ACKNOWLEDGEMENTS

I would like to thank Dr. Ellen Perecman and Professor Arlene Kraat for their extensive input and encouragement throughout this research endeavor. In addition, I would like to thank Drs. Louis Gerstman and Harold Shuckman for their time in reading and evaluating this dissertation. A special thanks to Dr. James Tweedy, who served as my major advisor, for his patience and many useful suggestions throughout the many phases of this study.

Many thanks to my fellow classmates and friends David Scarisbrick, Gail Kuslansky, Maria-Theresa Romero, Joyce Cochran and Allison Pratt for their support throughout my years at Queens College. Also, many thanks to Foster Henry for his video expertise, and the Psychology department secretaries for their willingness to always be of assistance. Thanks also to the subjects and their families for the time which they so willingly gave.

My sincere thanks to my family, particularly my husband, John A. Wheatland, Jr., for his constant love, encouragement, and emotional support, and my mother, Nella R. Corbin, who taught me that "whatever is worthwhile doing is worthwhile doing well". Also, thanks to my daughter, Nkenge Safiya, whose life has made me realize what is truly "important".

Finally, a special thanks to all those who struggled for the equal educational opportunity that allowed me to fulfill a dream.

TABLE OF CONTENTS

Page

APPROVAL PAGE iii
ABSTRACT iv
ACKNOWLEDGEMENTS vi
TABLE OF CONTENTS viii
LIST OF TABLES xiv
LIST OF FIGURES xvii

Chapter

I. INTRODUCTION 1

Hypotheses 2

II. REVIEW OF THE LITERATURE 7

Gesture in Aphasia: A Historical Perspective.......10
Processing of Gesture and Pantomime in Aphasic Subjects 14
Pantomime and Gesture Comprehension 14
Relationship Between Speech Comprehension and Receptive Gesture 14
Relationship Between Reading Comprehension and Receptive Gesture 19
Relationship Between Pantomime Symbolism and Receptive Gesture 25
Relationship Between Response Choice Relatedness and Receptive Gesture ..27
Pantomime and Gesture Production 28
Expressive Gesture Impairment: Apraxia 28
Limb-kinetic Apraxia 30
Ideomotor Apraxia 31
Ideational Apraxia 32
Relationship Between Apraxia and Severity/Type of Apraxia 32

Relationship Between Receptive
and Expressive Gesture 38
Relationship Between Expressive Speech
and Expressive Gesture 39
Relationship Between Apraxia and
New Motor Learning 40
Apraxia: Description of the Errors 42
Summary: Shortcomings of the Studies 46
Classification and Description of
Gestural Behaviors 47
Conclusions 51
Psychological Explanations of Gesture
Impairment 52
Asymbolia Theory 52
Modality Theory 63
Cognitive Theory 69
Anatomical Explanations of Gesture
Impairment 70
Apraxia Theory 70
Elaborations on Liepmann's Model 74
Geschwind 75
Heilman 79
Kimura 83
Gesture Impairment in Aphasia: Critique of
the Theories 89
Gestural Systems used in Aphasia
Rehabilitation 94
Non-language Gestural Systems 97
Pantomime 97
Limited Hospital or Center-based
Systems 98
Adapted Fingerspelling 99
Amer-Ind Gestural Code 99
Paget-Gorman Systematic Sign 101
Makaton Vocabulary 102
Sign Languages: American Sign Language ..102
Phonological Parameters 107
Acquisition Order Within Parameters ..115
Motoric Requirements 122
Conceptual Features 131
Manual Communication Training Programs With
Aphasic Patients 135
Discussion of Training Programs 136

Discussion of Training Outcomes 148

III. METHOD 152

Subjects 152
Experimental Design 155
Materials 156
Pretraining Tests 156
1. Type and Severity of Aphasia 156
2. Auditory Comprehension 157
3. Evaluation of Gesture Production
(Praxic Functioning) 159
4. Evaluation of Gesture Comprehension
...................................162
5. Subject's Desire to Communicate ...164
Signs 165
Randomization of Signs 168
Pictures 170
Procedure 170
Translucency Rating Procedure 170
Procedure for Identifying Signs Involving
Body Contact 171
Production Complexity Rank Ordering
Procedure 171
Handshape 172
Location 174
Movement 177
Orientation 180
Sign Training Procedure: Pretraining
Period 182
Informed Consent 182
Evaluation of Sign Knowledge 182
Presentation of Uses of Gesture In
Everyday Life 184
Training in Task Relevant Instructions
...................................184
Sign Training Procedure: Training
Period 184
Physical Guidance (Training) 186
Receptive Signing (Test) 187
Elicited Signing (Test) 187
Probes 187
Scoring Criteria 188

Inter-judge Reliability 191

IV. RESULTS 194

Summary of Pretest Results 194
Missing Data 200
Elicited Signing Results 200
Acquisition 201
Hypothesis 1 (Acquisition and Brain Injury 201
Hypothesis 2 (Acquisition and Production Complexity) 204
Relationship Between Acquisition and Production Complexity 208
Hypothesis 3 (Acquisition and Body Contact) 212
Hypothesis 4 (Acquisition and Translucency) 212
Hypothesis 5 (Acquisition of Parameters 213
Individual Aphasic Subjects Results ..214
Recall 218
Hypothesis 6 (Recall and Brain Injury) ..219
Hypothesis 7 (Recall and Production Complexity) 222
Relationship Between Recall and Production Complexity 223
Hypothesis 8 (Recall and Body Contact) ..225
Immediate Posttraining Recall (Test) 225
Same Day Recall (Probe 1) 226
One Week Posttraining Recall (Probe 2) 228
Relationship Between Recall and Body Contact 229
Hypothesis 9 (Recall and Translucency) ..229
Immediate Posttraining Recall (Test) 230
Same Day Recall (Probe 1) 232
One Week Posttraining Recall (Probe 2) 233
Relationship Between Recall and Translucency 235

Hypothesis 10 (Movement Errors and Brain Injury) 244
Hypothesis 11 (Movement Error Types Produced During Recall) 249
Individual Aphasic Subjects Results ..251
Hypothesis 12 (Recall and Parameter Errors) 254
Group Results 254
Individual Aphasic Subjects Results ..258
Hypothesis 13 (Relationship Between Gestural Deficit and Apraxia or Modality Deficit) 264
Relationship Between Gestural Deficit and Modality Deficit 267
Receptive Signing Results 269
Subsidiary Analyses 271
Influence of Sign Training Order on Mean Recall Scores 271
Acquisition and Recall of Signs in Sets A Through D Versus Sets E Through H 273
"No Response" Signs: Their Features 275
Aphasics 278
Controls 278

V. DISCUSSION 280

Summary of Results 280
Sign Acquisition and Recall in Aphasia 288
Asymbolia Theory 288
Modality Theory 291
Apraxia Theory 293
Specific Apraxia Errors Exhibited During Sign Execution 296
Parameter Errors 296
Movement Errors 301
Additional Issues 304
Sign Training Order 304
Perception of Sign Set Difficulty 305
"No Response" Signs 306
Practical Implications of the Results 306
Suggestions for Future Research 308

Appendix

A. Tactile Perception Test 310

B. Apraxia Battery 312

C. Desire to Communicate Evaluation Form 322

D. Pictorial Referents of Sign Stimuli 323

E. Determining the Translucency of Unimanual
Versions of Bimanual Signs 326

F. Production Complexity Descriptions and Values
for the Twenty-four Sign Stimuli 344

G. Informed Consent Form 346

H. Language and Praxis Profiles for the Eight
Aphasic Subjects 348

REFERENCES 365

LIST OF TABLES

Table

1. Subject Biographical Data 153

2. English Glosses of Sign Stimuli Organized According to Translucency, Body Contact, and Production Complexity 166

3. English Glosses for the Twenty-four Stimulus Items Organized into Sets 169

4. English Glosses of Sign Stimuli Rank Ordered According to Production Complexity 173

5. English Glosses of Sign Stimuli Organized According to Location, Handshape, and Movement 175

6. Developmental Sequence of Movement Patterns in the Production of Unimanual Signs 178

7. Notation For Five Palm Orientations 181

8. Developmental Sequence for Production of Five Palm Orientations 183

9. Mean Percent Scoring Agreement for the Twenty-Four Signs 193

10. Aphasic Subjects' Language Pretest Results 195

11. Aphasic Subjects' Praxis Pretest Results 196

12. Total and Mean Number of Sign Training Trials ..202

13. Total Number of Signs Acquired by Subjects 205

14. Mean Number of Training Trials for High and Low Production Complexity Signs 207

15. Percent Correct Responses on Sign Parameters by Individual Aphasic Subjects During Sign Acquisition 217

16. Mean Number of Parameters Recalled by Each Subject Under Strict and Lenient Scoring Conditions 220

17. Mean Recall Scores for High and Low Production Complexity Signs Under Each Scoring System ..224

18. Mean Recall Scores for Body-Contact (+BC) and Non-Body-Contact (-BC) Signs Under Each Scoring Condition 227

19. Mean Recall Scores for High, Medium, and Low Translucency Signs Under Each Scoring Condition 231

20. Mean Number of Movement Errors on Recall Evaluations For Each Subject Group 246

21. Mean Number of Three Types of Movement Errors Produced During Recall 248

22. Percent of Three Types of Movement Errors Produced During Recall 250

23. Percent of Each Movement Error Type Produced During Recall by Individual Aphasic Subjects 252

24. Percent Error on the Four Sign Parameters By Aphasics and Controls 256

25. Percent Error on the Four Sign Parameters by Individual Aphasic Subjects: Test Data 259

26. Percent Error on the Four Sign Parameters by Individual Aphasic Subjects: Probe 1 Data ...261

27. Percent Error on the Four Sign Parameters by Individual Aphasic Subjects: Probe 2 Data ...262

28. Correlations Between Praxis Subtests and Sign Acquisition and Recall Scores (Strict Scoring) 266

29. Correlations Between Selected Expressive Language Subtests and Sign Acquisition and Recall Scores (Strict Scoring) 268

30. Correlations Between Sign Training Order and Recall Probe Performance for Each Subject Group 272

31. Number of Recall Trials and Specific Signs Where No Response Was Produced by Each Subject 276

32. Summary of Major Findings Obtained From the Present Study 283

LIST OF FIGURES

Figure

1. Geschwind's schema 77

2. Heilman's schema 80

3. Scatter Plot of relationship between sign production complexity values and number of training trials (acquisition) required by aphasics 211

4. Percent of correct responses for each parameter during acquisition 216

5. Scatter plot of relationship between mean translucency and mean number of correct parameters on probe 1 for aphasics (strict scoring) 239

6. Scatter plot of relationship between mean translucency and mean number of correct parameters on probe 1 for controls (strict scoring) 241

7. Scatter plot of relationship between mean translucency and mean number of correct parameters on probe 2 for aphasics (strict scoring) 243

CHAPTER I

Introduction

Aphasia refers to a group of language disturbances caused by brain injury that affects the use of written and spoken language. Studies that have examined the gestural abilities of aphasic patients have found that gesture, like verbal language, is impaired in aphasia (Goodglass & Kaplan, 1963; Duffy, Duffy, & Pearson, 1975), although gestural skills typically are not as severely impaired as the spoken or written skills. Despite the general finding of gestural impairment in aphasia, recent applications of pantomime, Amer-Ind gestural code, and American Sign language (ASL) have shown that many nonfluent aphasics can benefit from training in the gestural modality (Bonvillian & Friedman, 1978; Kirshner & Webb, 1981; Heilman, Rothi, Campanella & Wolfson, 1979; Chen, 1968).

Unfortunately those studies that have been conducted generally have not included detailed descriptions of the subjects' language and motor impairments, prior to manual communication training.

These studies have also failed to systematically describe the particular training procedures, the variables that influence the acquisition of different gestures, and the specific type of errors made by aphasics when producing communicative gestures.

In light of the many procedural, theoretical and clinical questions remaining unanswered, it is difficult to understand why aphasic subjects experience success in the acquisition of manual communication skills.

The present study is designed to further investigate the ability of aphasic subjects to learn to produce ASL signs (acquisition), to recognize ASL signs, and to remember them over varying lengths of time (recall).

Hypotheses

Acquisition

The following directional hypotheses were advanced:

1. Brain-injured subjects (stroke victims) will require a greater number of initial training (handshaping and physical guidance) trials than non-brain-injured subjects to achieve criterion performance (one adequate sign performance or

completion of four training trials), and will acquire fewer signs.

2. For both aphasics and normal controls fewer training trials will be necessary to achieve criterion performance during acquisition of low production complexity (LPC) signs than during acquisition of high production complexity (HPC) signs.

3. For both aphasics and normal controls fewer training trials will be necessary to achieve criterion performance during sign acquisition of body-contact (+BC) signs than non-body-contact (-BC) signs.

4. For both aphasics and normal controls fewer training trials will be necessary to achieve criterion performance during acquisition of high as compared to medium translucency signs, for medium as compared to low translucency signs, and for high as compared to low translucency signs.

The following nondirectional hypothesis was also advanced:

5. No prior predictions were made regarding the hierarchy of acquisition for ASL parameters in aphasics and normal controls.

Recall

The following directional hypotheses were advanced:

6. Brain-injured subjects will produce a smaller mean number of correct sign parameters than non-brain-injured subjects on the three post training recall evaluations (immediate posttraining recall (test), same-day recall (probe 1), and one-week posttraining recall (probe 2)).

7. For both aphasics and normal controls low production complexity signs (LPC) will be produced with a higher number of correct sign parameters than high production complexity (HPC) signs on the three posttraining recall evaluations (immediate posttraining recall (test), same-day recall (probe 1), and one-week posttraining recall (probe 2)).

8. For both aphasics and normal controls a higher mean number of sign parameters will be performed correctly for body-contact (+BC) than for nonbody-contact (-BC) signs on the three posttraining recall evaluations (immediate posttraining recall (test), same-day recall (probe 1), and one-week posttraining recall (probe 2)).

9. For both aphasics and controls a higher number of parameters will be performed correctly for high as compared to medium translucency signs, medium as compared to low translucency signs, and high as compared to low translucency signs, on the three posttraining recall evaluations (immediate posttraining recall (test), same-day recall (probe 1), and one-week posttraining recall (probe 2)).

10. Brain injury will result in an increased mean number of movement errors being produced on the three posttraining recall evaluations (immediate posttraining recall (test), same-day recall (probe 1), and one-week posttraining recall (probe 2)).

The following nondirectional hypotheses were also advanced:

11. No prior predictions were made regarding the proportion of the three different types of movement errors (intrusions, duplications, and unrelated) that the two subject groups or individual subjects would produce during recall.

12. No prior predictions were made regarding the hierarchy of parameter errors that would be produced during recall of signs by aphasics and normal controls.

Acquisition and Recall

The following directional hypothesis was advanced:

13. The gestural deficit observed among aphasics during acquisition and recall will be largely attributable to a coexisting apraxia or modality deficit.

CHAPTER II

Review of the Literature

Communication, the process of transmitting or receiving messages, is an integral part of the human experience. Language is one of the vehicles through which man is able to communicate. Benson and Geschwind (1971) identify language skill as the ability to perceive verbal stimuli, integrate these stimuli with prior knowledge, and produce a verbal response. Language knowledge, according to Noam Chomsky, is an internalized system of rules that relate a specific sound, or signal, and meaning in a particular way (Chomsky, 1972; Klima & Bellugi, 1979). Because language is very important for expressing needs and ideas its disturbance can leave one isolated and sometimes frustrated. In the disorder known as aphasia brain damage results in the disturbance of language (Benson & Geschwind, 1971). The brain damage resulting in aphasia may be caused by a stroke, tumor, abscess or trauma, however, the vast majority of aphasic persons have had a stroke. The nonfluent type of aphasia is the most common due to stroke, and the younger the victim the more likely he/she is to suffer from this type of aphasia (Brown & Grober, 1983; Rose, 1984). Brown and Grober (1983) have also noted that among stroke victims in their thirties, nonfluent aphasias are more common in females than in males.

Current estimates place the number of new strokes in the United States that occur each year at about 400,000, with at least 84,000 (21%) accompanied by aphasia (Sarno, 1980). By one to three months poststroke severe language disturbance is estimated to be present in 10,000 (2.5%) of these patients (Sarno, 1980). Sarno (1980) estimates that there is a reservoir of about one million aphasics living in the United States presently. Because many of these individuals have experienced significant loss of receptive and expressive language skills they usually require extensive speech and language therapy. For some, there is failure to recover adequate spoken language even after intensive and prolonged therapy.

We are fortunate that an alternative to traditional therapeutic techniques has become available largely through the work of Gardner and Gardner (1971). These investigators examined whether a gestural system developed by humans, such as American Sign Language, could be learned and used by primates. Their research demonstrated that when such a gestural system is employed with primates it can result in effective communication acquisition, whereas primates cannot learn spoken language (Kellog, 1968). The gains documented in severely language disturbed children, after signing programs were implemented in their school curricula (Barnes, 1973; Peters, 1973; Brookner & Murphy, 1975; Grinnell, Detamore & Lippke, 1976; Konstantareas, Oxman & Webster, 1977; Shaeffer, 1980), have served to encourage some clinicians to consider signing as an alternative for facilitating communication in nonspeaking aphasic individuals. The pioneering work of Stokoe (1960) and Klima and Bellugi (1979) demonstrating that American Sign Language is a language in its own right, with a grammar and lexicon all its own, has provided additional support for this alternative.

In addition to the clinical usefulness of manual communication techniques investigators are beginning to realize that such methods have the potential to play an important role in the investigation of how the brain mediates language in a modality other than the auditory-vocal one.

<u>Gesture in Aphasia: A Historical Perspective</u>

Although training nonfluent aphasics to use gestures for communication is a relatively new idea, interest in the ability of aphasic individuals to manipulate nonverbal symbols is not new (Glass, Gazzaniga & Premack, 1973). For over one hundred years a major debate has been waged in the aphasia literature regarding whether there is a central symbolic deficit present in aphasia that affects both the verbal and nonverbal modalities, or whether the verbal and nonverbal modalities can be independently affected from the psychological point of view (Duffy & Liles, 1979).

In the early history of aphasiology the popular view was that aphasia was a disorder of speech only. Paul Broca (Broca, 1861) clearly distinguished between what he called articulated language (la faculté du langage articulé) and a general language faculty (la faculté général du langage). He defined the general language faculty as that which accounts for the ability to establish a systematic relationship between an idea and a symbol (Broca, 1861). According to Broca what was impaired in "aphemia" (Broca's term for aphasia) was articulated language, not symbolic functioning. He noted that in "aphemia" comprehension and gesture remain unimpaired, and concluded that the left hemisphere was primarily responsible for language execution.

Despite Broca's belief that articulated language was distinct from language comprehension and gesture it appears that he also realized that nonverbal deficits sometimes accompanied aphasia. In a discussion of his famous patient "Tan" Broca commented that although the man was able to use one word accompanied by varied gestures to express most of his ideas, there were certain questions for which a gestural response would have been appropriate to which he did not respond (Head, 1926; Broca, 1861).

In 1870 the view that aphasia only disturbed speech was challenged during a lecture given by a Dr. Finkelnburg (Duffy & Liles, 1979). Dr. Finkelnburg's thesis was that aphasia was not a specifically verbal deficit and that it was one aspect of a disorder he referred to as "asymbolia", which he defined as a generalized disturbance in the capacity to express and comprehend symbols in any modality. Finkelnburg presented five case studies of nonverbal impairment in aphasia. Three of the five patients were noted to demonstrate gestural deficits. Finkelnburg observed one female patient who had been raised a pious catholic and now "never initiated making the sign of the cross which, when healthy, she never neglected to do" (Duffy & Liles, 1979, p. 160). Another patient's gestures were observed to be "noticeably awkward and at times completely incongruous with what he meant to express" (Ibid, p. 162). The mimicry and gesticulation of a third patient was described as becoming "clumsier and less comprehensible" and his comprehension of pantomimes was characterized as "impaired". These observations lead Finkelnburg to develop the term "asymbolia", a term he felt more accurately described the verbal and nonverbal deficits exhibited by these patients. Finkelnburg's thesis has found support in recent years from investigators such as Duffy (Duffy, Duffy, and Pearson, 1975) and Pickett (1974).

Hughlings Jackson recognized that when a destructive brain lesion affects speech there are both positive and negative symptoms (Head, 1926). He listed the negative symptoms as the inability to speak, write or read, and express oneself by using signs. The positive symptoms or activities that the patient could perform were listed as writing his signature, swearing, or uttering other emotional expressions. Jackson further noted that, "in some cases of 'complete aphasia' there is some power of pantomime but...there is less than in healthy men and...in some cases of aphasia it is very much impaired" (Taylor, 1932, p. 206).

Goldstein (1948) considered the gestural impairment seen in mixed or global aphasia as part of a cognitive impairment of the "abstract attitude". However, he also recognized that gestures and pantomimes may remain intact in some aphasics as long as the abstract attitude is not impaired.

Alajouanine and Lhermitte (1964) also commented on the gestural ability of aphasics. These authors noted that in aphasia "the gestures associated with verbalization, or which replace it, are often reduced to some expressive movements without significant value..." (p. 169), though "there are cases where the gesture has a more precise significance and may express perfectly what speech was not able to do..." (p. 169).

Studies performed in recent years examining the gestural skills of aphasic subjects have confirmed the clinical observations made by the early aphasiologists. The focus of these studies has been to systematically observe the gestural skills of aphasics and offer possible theoretical explanations for the impairment observed. In the following sections of this review the findings of studies on gestural comprehension and production in aphasia will be discussed and interpreted.

Processing of Gesture and Pantomime in Aphasic Subjects

Pantomime and Gesture Comprehension

Relationship Between Speech Comprehension and Receptive Gesture

The first systematic study of gesture comprehension in aphasia was conducted by Pickett in 1974. Pickett developed an experimental test battery to investigate the relationship between gestural deficits and aphasia. The gestural battery included two tactile and six gestural tasks. Two of the gestural tasks examined gesture comprehension and the remaining four tasks examined gesture production. The same ten stimulus objects were employed for all tasks. These were the same ones used in administration of the Porch Index of Communicative Abilities (PICA). Pickett (1974) chose those ten PICA items in order to assure that any score variation between subtests could not be the result of unfamiliar and difficult stimuli. Both the PICA and the experimental test battery were administered to 25 normal individuals, for standardization purposes, and 28 aphasic patients. The correlations obtained between the PICA scores and the gestural battery were positive and very strong.

Due to serious statistical and methodological flaws, Pickett's results and conclusions have been challenged. First, the PICA was the independent measure, yet two of the six gestural subtests (G1 and G2) were identical to subtests II and III on the PICA. In the statistical analysis Pickett failed to partial out the identical tests. In addition to the serious statistical error, several other methodological problems further weakened the study: 1. etiology was not well controlled; three etiologies were represented - CVA, trauma and surgery; 2. seven of the 28 patients were bilingual; and 3. there was no discussion of the patient's treatment. Although the results and conclusions of this study are questionable, it served to stimulate additional research on the relationship between gestural deficits and aphasia.

In an attempt to advance the study of the nonverbal communicative deficits of aphasics Duffy, Duffy, and Pearson (1975) followed Pickett's study with an investigation of the relationship between pantomimic recognition and verbal deficits in aphasic and nonaphasic subjects. A 50-item Pantomime Recognition Test (PRT) was developed by the investigators as a nonverbal measure of receptive pantomimic ability. The Pantomime Recognition Test was presented along with three tests of verbal abilities, the Verbal Recognition Test, the Naming Test, and the PICA, to four groups of subjects: 44 aphasic, 30 right-hemisphere damaged, 26 subcortically damaged, and 30 normals. The subjects were matched for etiology, sex, age, education, time postonset and incidence of hemiplegia. The aphasics were found to exhibit a greater impairment of pantomime recognition and verbal ability than the other groups of subjects, and high correlations were obtained between impairment of pantomime recognition and impairment of verbal abilities in the aphasics. In this study the right CVA's also exhibited impaired performance on the pantomime recognition test though their performance was still not as impaired as that of the aphasics. A replication of this study was conducted by Duffy and Duffy (1981) and the results obtained were essentially the same. The aphasics were found to exhibit a significant defect in pantomime recognition and a strong relationship was found to exist between these deficits and their verbal impairment. However, the right CVA's in the Duffy and Duffy (1981) study were not found to be significantly impaired on pantomime recognition, as were those in the earlier study (Duffy et al., 1975).

One significant problem associated with the Duffy et al., (1975) study lies in the use of the PICA scores in the correlation with gestural impairment without partialling out the gestural subtests. Another problem involves the failure to investigate pantomime expression separately. Duffy et al., (1975) equated gestural comprehension with gestural expression by assuming that "there is only one underlying system basic to the decoding and encoding of language..." (p. 118), and proposed that either the comprehension or expression results could be used to describe the underlying communicative competence. This assumption finds little support in the literature. Rather it is believed that recognition and expression are two distinct types of behavior employing different cognitive structures.

Other weaknesses of the Duffy et al., (1975) study include: (a) the right CVA's were not examined for aphasia, despite the authors' note that some right CVA's may also have lesions that could produce mild aphasic symptoms; (b) aphasics were not classified according to types; (c) pantomimes were performed by one of three different examiners (d) there was no test for apraxia; and (e) the foils on the PRT were unrelated to the test item.

Another study that found a strong correlation between aphasic subjects' performance on measures of verbal and symbolic gestural comprehension was conducted by Gainotti and Lemmo (1976). Administration of the gestural comprehension test involved presenting the subjects with a card containing three pictures and requiring them to point to the picture related to the gesture or pantomime made by the examiner. It was found that more than half of the aphasic subjects were unable to comprehend the symbolic gestures. The investigators also found a significant correlation between verbal semantic impairment (evaluated by the number of errors obtained on a "verbal sound and meaning discrimination test") and the aphasic subject's inability to understand the meaning of symbolic gestures.

In a study conducted by Kadish (1978) gesture and pantomime impairment were examined from a neuropsychological perspective using Luria's theoretical framework for categorizing receptive and expressive gesture. Six aphasic subjects of varying etiology and severity were included in the study. There were no controls. Kadish found a significant relationship between speech comprehension and receptive gesture. It was concluded that receptive gestural ability is closely related to the various perceptual processes which are dependent upon Luria's second functional unit i.e., visuo-spatial organization and mnestic (memory) processing. Thus, Luria's conception of a common underlying neural substrate for receptive activities received support from Kadish's data.

Relationship Between Reading Comprehension and Receptive Gesture

Pantomime recognition has also been investigated in terms of its relationship to reading comprehension. One investigator who has been instrumental in encouraging research in this area is Nils Varney (Varney, 1978). In his first study Varney (1978) administered tests assessing pantomime recognition, reading comprehension, aural comprehension, and naming ability to 40 aphasic and 20 control patients. He found that for aphasics deficits in pantomime recognition always co-occurred with reading comprehension deficits of at least comparable severity, but not vice versa. Additionally, pantomime recognition was found to be only weakly associated with auditory comprehension and naming ability.

There were several aspects of Varney's results that remained unclear. First, only 1 of the 18 aphasics with impaired pantomime recognition showed normal auditory comprehension, also it was not known whether defects in pantomime recognition were consistently associated with other types of visually mediated cognitive impairment. In an attempt to clarify these theoretical issues Varney (1982) investigated the relationship of pantomime recognition to three relevant cognitive performances - sound recognition, alphabet letter recognition, and the WAIS Block Design subtest. His subjects were 44 right-handed aphasic patients not classified according to type, or site of lesion. Among the 44 aphasics, 30 had vascular lesions, 13 had neoplastic lesions, and one had a lesion due to head trauma. No control subjects were tested. Each subject was administered a 30-item videotaped PRT which involved pointing to a drawing of the object whose use was demonstrated from among four choices. The results of this test were compared to a 26-item sound recognition test, a 20-item letter recognition test, and the Block Design subtest from the Wechsler Adult Intelligence Scale (WAIS).

As was found in Varney's earlier study (Varney, 1978), aphasic scores on pantomime recognition were highly variable and defects in pantomime recognition were closely associated with defects in reading comprehension. Furthermore, reading comprehension was always at least as impaired as pantomime recognition. Close relationships were not indicated between pantomime recognition and sound recognition or letter recognition.

Another study (Ferro, Santos, Castro-Caldas & Mariano, 1980) that investigated gestural recognition in aphasia obtained results similar to Varney (1978, 1982). A Gesture Recognition Test (GRT) was administered to 111 aphasic patients, all with lesions of vascular origin, and 48 normal controls. Forty-three percent of the aphasics exhibited gesture recognition impairment and Global, Wernicke's and

Transcortical aphasics performed worse than Broca's, Conduction and Anomic aphasics, whose performance was not significantly different from that of the controls. The three groups of aphasics whose gestural recognition performance was defective also exhibited poor auditory comprehension. However, the correlation between their gesture recognition disability and the severity of their auditory comprehension impairment was only moderate. Moreover, 19% of the aphasics with severe auditory comprehension defects had a normal gesture recognition performance. Therefore, the type of aphasia had an effect on gesture recognition that was apparently independent of the severity of the auditory comprehension impairment. Based on their results the authors concluded that auditory comprehension is not a prerequisite for gesture recognition.

In accordance with Varney's (1978, 1982) work GRT impairment was associated with reading defects only in patients with central alexia. These findings were especially important "...because they showed that the correlation between GRT and central alexia is more 'universal'-i.e. present in more aphasia subgroups and reached higher values than those found with any of the aphasia tests" (Ferro et al., 1980, p. 284). Although these results are even more robust than Varney's (1982), they must be considered in light of differing methodologies and qualitatively and quantitatively different stimuli. Ferro et al. (1980) administered 12 stimuli versus Varney's (1982) 30 and Duffy and Duffy's (1975) 46. Also, Ferro et al. (1980) failed to include any semantic foils in their matrix of three items, and there was no examination of pantomime imitation or production. Despite the methodological issues mentioned, this study had many strengths. This was the first gestural study which examined the six aphasic subtypes, all associated with a CVA. Finally, the subjects were extensively pretested, which allowed posthoc analysis regarding the association of ideomotor apraxia and aphasia.

Seron, Van Der Kaa, Remitz, and Van Der Linden (1979) have also obtained results indicating that pantomime recognition is more strongly correlated with reading comprehension ($r = .64$) than with oral comprehension ($r = .48$). These investigators were interested in reconsidering Varney's hypothesis regarding the possible cause of the reading comprehension deficit observed in some aphasics. Pantomime interpretation was examined in 27 (14 Wernicke's, 9 Broca's, and 4 Global's) right-handed aphasic patients (93% vascular lesions). The scores obtained by 74% of the aphasics were lower than those of the normal control subjects, and the difference between aphasics and normal subjects was highly significant. Additionally there was no relationship found between pantomime recognition test performance and the severity of aphasia, time post onset, or lexical semantic disturbances. The authors suggested instead that one determinant of the disorder was the "plausibility" of the relation between the represented gesture and the object chosen. By "plausibility" they meant that the incorrect choice often shared movement (the gestures associated with two objects utilize similar movements) and location (the gestures associated with two objects are made at similar locations on the body or in space) characteristics with the correct choice. The authors concluded that since the gestural relations were not strongly expressed at a semantic/lexical level the plausibility factor is probably not linguistic in nature but rather motorically based.

Finally, a recent study conducted by Dr. Paul Rao (1985; 1986), investigating Amer-Ind sign comprehension and production by aphasic adults, also found a strong relationship between reading comprehension and gestural recognition. In this study several variables were examined for their relationship with gesture recognition. Reading was found to be the most potent predictor of gesture comprehension, accounting for over 50% of the variance in the gesture recognition performance.

<u>Relationship Between Pantomime Symbolism and Receptive Gesture</u>

Duffy and McEwen (1978) have examined the relationship between pantomime symbolism and pantomime recognition in aphasics. The study was designed to test Jenkins, Jimenez-Pabon, Shaw, and Sefer's (1975) hypothesis regarding the effects of brain damage on "signal" (gestures having a nonarbitrary relationship to their referent) and "symbolic" (gestures having an arbitrary relationship to their referent) nonverbal communication. Jenkins et al., (1975) hypothesis implicates the right hemisphere as specialized for "signal" nonverbal communication and the left hemisphere for "symbol" nonverbal communication. Duffy and McEwen (1978) evaluated whether "signal" pantomimes are easier to understand than "symbol" pantomimes. The subjects were the same ones used by Duffy et al., (1975). Overall, the results on the 27 pantomimed items were in the predicted direction; that is the pantomimes most difficult for aphasics to recognize were the more arbitrary ones. However, examination of the performance on individual pantomimes revealed that Jenkins et al., (1975) hypothesis was not supported. Specifically, some pantomimes rated as very arbitrary did not receive a low pantomime recognition score. The authors concluded that the degree of symbolism (arbitrariness) could not account for the increased number of errors in the aphasic subjects' pantomime recognition scores.

A major weakness of Duffy and McEwen's (1978) study was the omission of right CVA's in the control group. The hypothesis tested referred to the brain's asymmetry for processing two types of gestures, yet the authors neglected to examine the other side of Jenkins' hypothesis, namely that right-hemisphere damage should affect signal pantomimes as opposed to symbol pantomimes. Examination of this issue is especially pertinent since in Duffy et al., (1975) the right hemisphere CVA's exhibited a significant pantomime recognition defect.

Relationship Between Response Choice Relatedness and Receptive Gesture

An interesting study deriving from Varney's research was conducted by Varney and Benton (1982). The study investigated the performance pattern of 144 right-handed aphasic patients (67% vascular, 27% tumor, 6% head trauma) and 30 controls, on a pantomime recognition test in which one of the four response alternatives was an object semantically related to the correct choice. The remaining two foils were a neutral foil (an object bearing no relationship to the stimulus in function or pantomimed use, but which was a correct choice elsewhere on the test) and an odd foil (an object whose use could not be pantomimed). Aphasics with defective pantomime recognition scores made more semantic errors (71% of their total errors) than any other type. The results were interpreted to mean that these aphasics were impaired in pantomime recognition because of a "semantically vague" understanding of the pantomime's intended meaning and not because of a complete lack of understanding of the pantomime. The nonrandom nature of the aphasic's errors suggest that some aspects of the pantomimes were being processed.

Another study that examined the effect of response choice relatedness on pantomime and verbal recognition ability was conducted by Duffy and Watkins (1984). These investigators explored this issue using 20 aphasic and 20 normal control patients who were administered pantomime and verbal recognition tests that contained related and unrelated response choices. The results indicated that the presence of conceptually/semantically related response choices on the pantomime and verbal recognition tests significantly reduced the aphasic subjects' performance.

Pantomime and Gesture Production

Expressive Gesture Impairment: Apraxia

Gesture production (disorders of skilled movement) has also been noted to be impaired in some aphasic subjects. Hugo Liepmann proposed the term motor apraxia to describe disorders of skilled movement not caused by poor comprehension, motor or sensory defects, or intellectual deterioration (Liepmann, 1900/1977). Although Hughlings Jackson (Taylor, 1932) was the first to describe apraxia, it was Liepmann who sparked interest in these disorders. From Liepmann's careful clinical observations came a description of the apraxic disturbances of one patient who exhibited unilateral apraxia on the right side of the body and no corresponding disturbance on the left side (Liepmann, 1900/1977). The patient was able to perform skilled movement to command and imitation as well as use objects correctly with the left hand. Liepmann (Kimura, 1980) later described a patient with right hemiplegia who could not use his left limbs to perform skilled movements to command or imitation. Postmortem examination revealed that the patient's lesion was in the basis pontis and the corpus callosum sparing the splenium of the corpus callosum. Liepmann (Kimura, 1980) realized that the patient's apraxic deficit could not be fully explained as due to disconnection of motor areas in the right hemisphere from language areas in the left hemisphere. Because the patient's right hemisphere was also essentially intact, Liepmann (Kimura, 1980) concluded that the left hemisphere contains not only language, but also memory for learned movements or "motor engrams" (Goldstein, 1970; Heilman, 1979). The corpus callosum lesion, therefore, did not only disconnect the dominant hemisphere from the hemisphere controlling the left hand, but it also isolated the motor engrams in the left hemisphere from motor areas in the right hemisphere. Liepmann proposed the term "sympathetic apraxia" to refer to this type of apraxia. The concept of the motor engram was an essential part of Liepmann's description of the various types of limb apraxia. He considered the motor engram essential for controlling and evoking the temporal sequence and spatial arrangement of the single movements composing an action. The several varieties of limb apraxia described by Liepmann are presented below.

Limb-kinetic apraxia. Limb-kinetic apraxia is a disorder of fine learned movements that is most clearly observed in the distal digits (fingers) (Brown, 1972). The lesions associated with limb-kinetic apraxia have not been clearly delineated. Liepmann (cited in Heilman & Rothi, 1985) postulated that lesions in the sensory motor cortex may induce this disorder, but, Brown (1972) proposes that the lesion responsible may be in the premotor region of the dominant hemisphere. Pyramidal lesions have also been linked with limb-kinetic apraxia (Benson & Geschwind, 1971; Heilman & Valenstein, 1985).

Ideomotor apraxia. Ideomotor apraxia is the inability to carry out a motor activity in response to a verbal request, though it can be performed with ease spontaneously (Benson & Geschwind, 1971). When asked to pantomime the use of an object patients suffering from this disorder have difficulty sequencing the various movements required to adequately complete the act. Ideomotor apraxia is frequently seen in the aphasic population and can be caused from lesions to three different cortical sites. A lesion in the arcuate fasciculus allows the patient to comprehend the command but interferes with the ability to carry it out (Benson & Geschwind, 1971). A lesion involving the dominant motor association cortex destroys the origin of the pathway across the corpus callosum and often results in Broca's aphasia as well. Lesions of the motor association cortex usually encompass the adjacent motor cortex resulting in hemiplegia in the limb served by the dominant hemisphere. The limb controlled by the opposite hemisphere will also perform poorly to command and imitation, demonstrated "sympathetic apraxia" (Liepmann 1900/1977; Benson & Geschwind, 1971; Kimura, 1980). Finally, a lesion that involves the anterior corpus callosum or the callosal fibers deep in the white matter of either frontal lobe allows commands to be carried out with the dominant limbs but not those of the nondominant side.

Ideational apraxia. There are currently two definitions of ideational apraxia. Liepmann (Kimura, 1980) defines ideational apraxia as the inability to carry out an activity requiring several steps, although the individual steps can be performed in isolation. Ideational apraxia is alternatively defined as an inability to demonstrate the intended use of an object (Heilman & Valenstein, 1985). Presently there is no consensus on whether the two disorders are independent or whether as the disease progresses patients may exhibit profound conceptual defects that ultimately lead to an inability to use objects properly (Heilman & Rothi, 1985; Benson & Geschwind, 1971).

Relationship Between Apraxia and Severity/Type of Aphasia

In 1908 Liepmann (Kimura, 1980) recognized an association between apraxia and speech disturbances. In his population of 20 patients 70% exhibited severe speech disturbances, while of the 21 nonapraxic patients only 4 or 19% had aphasia. Since Liepmann's observation others have also noted the relationship between aphasia and apraxia (Goodglass and Kaplan, 1963; DeRenzi et al., 1968; Ettlinger, 1969; Dee, Benton, & Van Allen, 1970; Geschwind, 1975; DeRenzi et al., 1980; Kertesz & Hooper, 1982).

The particular association between aphasia and ideomotor apraxia has usually been viewed in two ways (Feyereisen & Seron, 1982). Either ideomotor apraxia and aphasia are independent disorders that are caused by large brain lesions extending into areas related to both functions, or the two disorders are caused by damage to the left hemisphere mechanisms specialized for the control of complex motor sequences that happen to lend themselves to communication (Kimura, 1976).

Goodglass and Kaplan (1963) conducted the first "gestural" study of brain-injured adults. They also examined the severity of the gestural disturbance in aphasics and compared the results to those of nonaphasic brain-damaged patients. These investigators also examined the relationship between gestural deficiency and severity of aphasia, and whether a praxic disorder could exist while the ability to imitate remained intact. Using three gestural expression tests ("natural" expressive gestures, "conventional" gestures, and "simple" pantomime) aphasics were found to perform more poorly than the nonaphasic brain-damaged controls. Additionally, no relationship was found between severity of aphasia and severity of apraxia, and aphasics were found to have a deficit in gestural imitation.

Despite its importance, Goodglass and Kaplan's (1963) study contained several methodological problems: (a) Their aphasic subjects had variable etiology and were not separated into subtypes, (b) a standardized aphasia examination was not used to determine severity of aphasia, (c) pretests for apraxia and gestural recognition were not administered, (d) severe receptive and global aphasics were excluded, and (e) instructions to subjects were only given verbally.

A later study conducted by DeRenzi, Motti, and Nichelli (1980) also found that aphasics performed poorly on expressive gesture tasks. DeRenzi et al., (1980) studied a total of 280 right-handed subjects. The subjects were classified as follows: 100 non-neurological controls, 80 right-hemisphere damaged, and 100 left-hemisphere damaged subjects (60 aphasics separated according to type and 40 nonaphasics). Eighty percent of the brain-damaged subjects were of vascular etiology. Two experimental tasks were administered. The first task was The Movement Imitation Test (MIT), which required the subjects to imitate movements classified according to three dimensions (a) symbolic versus nonsymbolic, (b) independent finger movements versus whole-hand movements, (c) and static postures versus kinetic sequences. The second task was a Demonstration of Use Test, which examined the use of ten common objects. The results indicated that the aphasics performed most poorly on the experimental tasks; 80% of the aphasics performed in the apraxic range, while 5% of the left-hemisphere nonaphasic group performed below the cut off. The incidence of apraxia with regard to the aphasic subtypes revealed no significant difference between the performance of Wernicke's and Broca's aphasics. However, global aphasics were found to be significantly more impaired than Wernicke's and Broca's aphasics. An interesting finding was that 20% of the right-hemisphere damaged patients also performed in the apraxic range. The authors proposed that the right-hemisphere results may be due to a clinically undetected left-hemisphere lesion.

On the MIT the general findings were the same for all subjects. There was no significant difference found between finger movements versus whole-hand movements, static postures versus kinetic movements, or symbolic versus nonsymbolic gestures. However, there was a general tendency for all subjects to do better on finger versus whole-hand and static versus kinetic movements. Among the aphasics 31 were found to be apraxic on both postures and motor sequences.

DeRenzi et al., (1980) also examined the extent to which the intransitive movements evaluated by the MIT were comparable with movements requiring the use of objects (transitive movements). A correlation was computed between the imitation test scores and the demonstration of use test scores for 50 of the left brain-damaged subjects. The correlation of .80 obtained suggests that the two tests measure approximately the same abilities, therefore the issue of transitivity may not be relevant with regards to gestural imitation.

Finally, DeRenzi et al., (1980) examined the relationship between apraxia and language impairment by correlating the aphasics' Token Test scores with their performance on the MIT. A significant relationship was found between the two impairments, although the correlation was not particularly high (r = .56).

Kertesz and Hooper (1982) examined the extent and characteristics of apraxia in various aphasic subgroups. Two hundred and thirty aphasic patients were given the Western Aphasia Battery (WAB) and a praxis test consisting of 20 items in four categories (facial, intransitive-upper limb, transitive-object use, and complex). The etiology of most of the aphasic subjects was stroke although there was a small number with tumor, trauma, and degenerative disease. The subjects were grouped into eight diagnostic subgroups based on their performance on the WAB. Global aphasics were found to be the most apraxic, while Broca's aphasics were slightly more apraxic than Wernicke's. Transcortical and conduction aphasics had similar praxis scores, and anomic aphasics had the best scores. The finding of the most severe apraxia in global aphasics was attributed to their large lesion which was hypothesized to have extended into cortical areas responsible for both praxis and language. A finding at variance with Goodglass and Kaplan's (1963) was the high correlation (r = .73) with severity of aphasia as measured by the Western Aphasia Battery. These results were attributed to the difference in size and composition of the subject groups from both studies. Goodglass and Kaplan included 20 mildly impaired aphasics compared to Kertesz and Hooper's population of 230 patients exhibiting varying degrees of language impairment. Two additional important findings were that there was no significant difference between "anterior" and "posterior" aphasics matched for severity, and that oral apraxia was more marked than limb apraxia in Broca's and transcortical motor aphasia. Methodological weaknesses associated with this study include the mixed etiology of the aphasic population and the lack of computerized tomography (CT) evidence to support diagnoses.

Relationship Between Receptive and Expressive Gesture

In addition to examination of their subjects pantomime recognition skills, Gainotti and Lemmo (1976), whose study was discussed earlier, examined the relationship between their subject's gesture reproduction skills and gesture comprehension. Eighty-one percent of the aphasic subjects who performed in the apraxic range on the gesture reproduction task were found to be impaired on gesture comprehension as well. However, only 50% of the aphasics that were not apraxic exhibited an impaired performance on the gesture comprehension task.

Another study that investigated the relationship between gesture comprehension and ideomotor apraxia was conducted by Rothi, Heilman, and Watson (1985). They employed a task where pantomimed acts were shown on videotape to six apraxic-aphasic patients, seven non-apraxic-aphasic patients, and six normal subjects. Corresponding to each videotaped pantomime four drawings were shown, the target picture and three foils, and subjects had to choose the appropiate picture. The results obtained were similar to those of Gainotti and Lemmo (1976): the apraxic aphasics made the most errors, followed by the nonapraxic aphasics, and the normal controls made the least number of errors. Therefore, the relationship between gesture comprehension and gesture reproduction may vary as a function of the presence and severity of apraxia (Christopoulou & Bonvillian, 1985).

Relationship Between Expressive Speech and Expressive Gesture

In Kadish's (1978) study, which was discussed earlier, both the relationship between speech comprehension and receptive gesture and expressive speech and expressive gesture were examined. Kadish found a significant relationship between receptive and expressive gesture ($r = .86$, $p = .05$) and between speech comprehension and receptive gesture ($r = .87$, $p = .05$), however, no significant relationship was found between speech production and expressive gesture. Although, the results regarding expressive gesture and speech did not support any strong conclusions, Kadish offered a possible explanation for the gestural production impairment. It was suggested that such a deficit may be best understood as a breakdown in complex sequential manual motor activity, such as proposed by Kimura (1979).

Relationship Between Apraxia and New Motor Learning

Since ideomotor apraxics have been found to be defective in pantomime production (Goodglass & Kaplan, 1963), meaningful imitation (Goodglass & Kaplan, 1963), and meaningless imitation (Kimura & Archibald, 1974), Heilman, Schwartz and Geschwind (1975) conducted a study to examine whether these apraxics are also defective in acquisition and retention of new motor skills. Nine right-handed, hemiparetic, aphasic apraxics served as the subjects and eight right-handed hemiparetic, aphasic, nonapraxics served as controls.

Each subject was given six trials on a rotary pursuit apparatus (five acquisition trials and one retention trial administered after a delay). Subjects were instructed to use their left nonparetic hand. The results indicated that the nonapraxic control group performed significantly better on the last trial, which followed a delay, than the first trial. Performance for the apraxic group did not differ significantly between the first and sixth trial. The authors interpreted the results as indicating that ideomotor apraxics exhibit a defect in motor learning caused by a combined impairment of both acquisition and retention.

In another study (Rothi & Heilman, 1984) where the acquisition and retention of a list of gestures by aphasic apraxics, nonaphasic apraxics, and normal subjects was investigated, aphasic-apraxic subjects were generally found to be the most impaired. They had a slower rate of acquisition, a shorter list of acquired gestures, and fewer total number of responses produced.

Kimura (1977) and Jason (1985) have also conducted studies on the acquisition of motor skills following left-hemisphere lesions. Both investigators' results confirm the observation of Heilman et al., (1975), that left-hemisphere lesions impair new motor learning. Additionally, in Jasons's (1985) study left frontal and left temporal lesions were most often associated with impaired learning of manual sequences.

Apraxia: Description of the Errors

Over the years very little research has been conducted on the nature of the movement errors produced by aphasic patients. Unlike work on the language impairments of aphasics, detailed descriptions of their expressive gesture errors have been limited. Much of the problem stems from the reluctance of investigators to expand beyond Liepmann's method of scoring gesture performance as either correct or incorrect. What is needed are scoring techniques that carefully delineate the type of errors produced, and allow the data to be subjected to mathematical analyses. The few studies that have been conducted on the nature of gesture errors in aphasia will be discussed below.

Kimura (1977) conducted one of the first studies where analysis of the expressive gestural errors produced by brain damaged subjects was done. Left and right-hemisphere damaged subjects were videotaped while they performed a complex motor task. Five major types of errors were noted: unrelated (movements bore no clear resemblance to any of those required on the task), perseveration (movements or postures which resembled the immediately preceding one), sequence (movements resembling those appropiate for other positions other than the immediately preceding one), incomplete (movement insufficient to adequately perform task), and holding (holding a task related movement an inordinately long time). It was found that particular error types were primarily associated with specific subject groups. Left-hemisphere damaged patients were found to produce a higher incidence of perseveration and unrelated errors, with the aphasic subjects producing the largest amount of both types of errors.

Haaland and Flaherty (1984) examined the different types of limb apraxia errors made by patients with left- versus right-hemisphere damage investigating both transitive (pretend object use) and intransitive (symbolic) movements separately. Seven error types were identified: (a) hand position, (b) arm position, (c) orientation of hand or arm, (d) partial errors (errors not severe enough for other categories, and two forms of body-part-as-object errors (e) BPO-1, part of body used as object, (f) BPO-2, hand in correct location but fist touched target. These authors found no difference between the right- and left-hemisphere damaged groups on the representative and nonrepresentative movement errors, however, differences emerged on the object use measures (transitive). The left-hemisphere group made more arm position and BPO-1 errors, and the right-hemisphere group made partial errors and more BPO-2 errors than the left-hemisphere group.

In a study conducted to assess the ability of left- and right-hemisphere damaged patients to generate novel finger positions and meaningful gestures, Jason (1985) found that the predominant errors produced were various types of perseverations. This observation was also made by Lehmkuhl, Poeck, and Willmes (1983; Poeck, 1985). Lehmkuhl et al. (1985) had investigated oral, leg, arm, and bimanual movements in 88 patients diagnosed with four different types of aphasic syndromes. They found that perseveration was the most prominent error across all four types of aphasia.

The most recently developed scoring system was produced by Gonzalez-Rothi, Heilman, Mack, Verfaille, and Brown (in press) to capture the nature of the left hemisphere's contribution to praxis. This system is a modification of the system used by Klima and Bellugi

(1979), which is based on the work done by Stokoe (1960) to capture the structure of ASL. Nine aphasics and 9 normal controls were studied. All the aphasics had suffered a unilateral CVA localized by CT. The subjects were asked to show how to use a tool, utensil, or object, and the performances were videotaped. There were significant differences found between the groups on the production of various types of errors. The scoring system allowed these investigators to describe six error types that characterize the apraxic patient. These include spatial distortions including body-part-as-object (BPO) errors, internal configuration (finger/hand posture), external configuration (orienting fingers/hand/arm in space to the imagined object), movement errors, and occurrence errors (multiplication or reduction of movements).

Use of scoring techniques like those developed to analyze ASL appear to offer the most promise in allowing the description of praxic errors. It is hoped that investigators will continue to explore different methods of gesture error analysis because it is through work like this that a better understanding of the disorder known as apraxia will be achieved.

Summary: Shortcomings of the Studies

The studies discussed above have served to facilitate understanding of many of the issues associated with receptive and expressive gesture impairment in aphasia. However, despite the important information provided by the research some of the studies have methodological and statistical flaws which influence interpretation of the results.

One important variable that has not been well controlled in many of these studies is the cause of the aphasic disturbance. Many studies include subjects with variable etiology such as stroke, tumor, and head injury. The reason for concern is that although CVA's generally result in localized lesions, head injuries and tumors may have more diffuse effects. Of particular concern is the use of head injury patients whose brain injury may be more wide spread than even radiological evaluations can determine (Levin, Benton, & Grossman, 1982). Although to a large extent brain tumors act as localized lesions, having a similar effect on behavior as a stroke, tumors may additionally compromise behavior by increasing intracranial pressure (Lezak, 1983).

Many of the studies also have not included important descriptive information regarding the aphasic subjects. For example, aphasia subtypes were delineated in only 35% of the studies and only one study (Kadish, 1978) described the type of language therapy the subjects had received.

Subject selection criteria has also been questioned. In two studies certain types of aphasic patients were excluded for no adequate reason: Goodglass and Kaplan excluded severe receptive and global aphasics, and Feyereisen (1983) excluded less severe cases and global aphasics. The inclusion of control subjects for comparison purposes has also been absent from several studies (Kadish, 1978; Daniloff et al., 1982; Varney, 1982)

The testing of praxis prior to examining gesture recognition or gesture expression is an important issue particularly when results are obtained showing certain subjects to be more impaired in terms of expressive gesture. However, pretests for apraxia were only administered in two studies (Gainotti and Lemmo, 1976; Ferro et al., 1980).

<u>Classification and Description of Gestural Behaviors</u>

A major shortcoming of the studies on gesture and aphasia is the lack of consensus on classification and description of gestural behaviors. Hecaen and Albert (1978) interpret the absence of a comprehensive and systematic classification system for gestures as "a major obstacle to the goal of understanding the physiological basis of gestural behavior and its breakdown" (p. 90). According to Hecaen and Albert (1967) if gestures could be organized into a system of signs, "the relationship of gestures to linguistic activities could be more clearly established".

Hecaen (1985) proposed a classification of gestures based on the relationship between a gesture and its intended meaning. This analysis was influenced by Pierce's (1932) three part categorization of gestures into "symbolic", "iconic", and "indicative" types, and Jakobson's (1964) notion of temporal relations. According to Hecaen (1985) "symbolic" gestures may or may not be highly codified, and are artificially linked to their referent; "Iconic" gestures are expressive reactions or pantomime behavior, where the gesture and its meaning are synonymous; while "indicative" gestures describe an object's function or use and are usually performed with the object present. Schuell (Jenkins, Jimenez-Pabon, Shaw & Sefer, 1975) employed a similar classification scheme distinguishing "symbol communiques", gestures bearing an arbitrary relationship to the referent, from "signal communiques", gestures that have a pictorial relationship with the referent. Jackson proposed that pantomime should be carefully distinguished from gesticulation (Taylor, 1932). He defined pantomime as a gesture that signifies a proposition (a thought or idea), gesticulation, on the other hand, was described as an emotional gesture that accompanies speech.

In their study examining the disturbance of gesture and pantomime in aphasia, Goodglass and Kaplan (1963) further divided gesture and pantomime. Gesture was subdivided into "natural expressive gesture" (direct action picture movements), versus "conventional gesture" (stylized descriptions of actions). Pantomime was divided into "simple" or single movements, versus "complex" or sequential movements.

An additional differentiation between "pantomime", "gesture", and "gesticulation" was proposed by Pickett (1974). He viewed "pantomime" as a sequential series of body movements; gesticulation was viewed as a group of random or sequential movements and "gesture" as a singular movement with meaningful intent.

In the study done by Kadish (1978) gesture and pantomime were considered synonymous. However, a formal distinction was made between the recognition of gesture (receptive gesture) and performance of gesture (expressive gesture). Kadish defined "receptive gesture" as the translation of a visuo-perceptive phenomenon (visuospatial sequential manual postures) into a symbolic system; "expressive gesture" as the encoding of information into sequential motor movements superimposed on manual postures.

The final classification scheme to be described was developed by Foldi, Cicone and Gardner (1982). These investigators divided limb gestures into four types: "emphatic" and "rhythmic" movements, "pointing" gestures, "emblems", and "pantomimes". "Emblems" are simple gestures which have a culturally accepted meaning while "pantomimes" refer to objects, actions, and attributes used to depict complex events. Emblems and pantomimes were further identified as gestures that "always make reference to some meaningful aspect of the world".

The use of various classification schemes to describe gestural performance continues as one of several shortcomings in the research on gesture in aphasia. It is hoped that current and future investigators will learn from the mistakes of the past so that they are able to conduct experiments that are more methodologically sound as well as consistent regarding their definitions of gesture.

Conclusions

It is clear that many of the studies done to investigate the gestural skills of aphasics are in agreement that there are a subset of aphasics who are impaired in gesture or pantomime comprehension and production. However, there is little consensus on the underlying causes of these nonverbal deficits. Explanations have been proposed that can be conceptualized in accordance with four theoretical perspectives: central symbolic deficit (asymbolia), apraxia, breakdown in information processing in one or several modalities (modality), and cognitive impairment. In the following section of this review the studies of gestural comprehension and production in aphasia, discussed earlier, will be interpreted in relationship to the four theoretical models delineated above.

Psychological Explanations for Gesture Impairment

Asymbolia Theory

The first theory to be discussed proposes that the human brain possesses one central communication and symbol system which when damaged results in impaired performance on all tasks that require manipulation of symbols. Manipulation of symbols is understood as the process of putting something (the sign) in place of something else (the referent). Proponents of this theory regard aphasia as a disturbance in this representational process, which is also involved in many cognitive operations (Feyereisen & Seron, 1982).

Pickett (1975) was one of the first investigators to interpret the positive correlations he obtained between language test scores and gesture test scores, as supporting Finkelnburg's asymbolia hypothesis (Duffy & Liles, 1979). Other's who have been strong advocates of this theory are Robert and Joseph Duffy (Duffy et al., 1975; Duffy & Duffy, 1981, Duffy, 1987). The basis for their strong support is their extensive research that has consistently found aphasic patient's pantomime recognition skills to be considerably poorer when compared to nonaphasic brain-damaged individuals and normal controls.

In an attempt to provide powerful evidence in support of the asymbolia hypothesis Duffy and Duffy (1981) published a comprehensive series of three related studies describing the pantomimic expression and recognition deficits found among aphasics. The first study was a replication of the Duffy et al., (1975) exploration of aphasic deficits in pantomime recognition. The results closely duplicated those of the 1975 study which found that aphasics exhibit a significant defect in pantomime recognition and that there exists a strong relationship between these deficits and their verbal impairment. The earlier finding that right CVA's were significantly impaired on pantomime recognition was the only result not duplicated in Duffy and Duffy's (1981) later study.

The purpose of the second study was to investigate the performance of aphasics on tests of pantomime recognition and pantomime expression, and compare the results to those of nonaphasics. In addition, the relationship between pantomime expression and recognition and three verbal measures (naming, verbal recognition and PICA) was examined. The specific assumption tested, which was presented in Duffy et al., (1975), was that "...competence underlying gestural communication may be inferred from either gestural expression or gestural reception" (p. 119). The Pantomime Recognition Test (Revised) (PRT) (Duffy and Duffy, 1981) and Pantomime Expression Test (PET) (Duffy and Duffy, 1981) were administered to 47 aphasics, 27 right-hemisphere damaged, and 11 control patients. The results obtained demonstrated that aphasic subjects were deficient in both pantomime expression and recognition when compared to nonaphasics. The authors also obtained a high correlation between pantomime recognition and pantomime expression, thus acquiring experimental support for the assumption that either nonverbal task may be used as an index of an underlying communicative competence. In further support of the assumption, pantomime recognition and expression were found to correlate as strongly with each other as with the PICA, the Verbal Recognition Test, and the Naming Test. The authors proposed that there are two factors that affect the relationship between verbal and nonverbal tasks. The most important factor is a single general symbolic impairment that underlies all tasks. The second factor, considered less significant, relates to the influence of modality on the strength of the verbal-nonverbal relationship. It was found that the more similar the performance behaviors the stronger the relationship. Therefore, the two motor tasks and the two visual tasks were more strongly related than mixed motor and visual tasks.

In the third study of the Duffy and Duffy (1981) investigation, three competing theories regarding the cause of aphasic deficits in pantomime expression were examined. The theories examined were that gesture impairment in aphasia is the result of : 1. damage to a central symbolic process, 2. conceptual deficits which result from a general intellectual impairment associated with brain injury, and 3. a limb apraxia which sometimes accompanies aphasia. The relationship between pantomime expression and each causal variable was investigated by correlating the performance of the aphasic subjects on the Pantomime Expression Test (PET) with their performance on measures of general intelligence (Raven Progressive Matrices), limb apraxia (Manual Apraxia Test, Duffy, 1974), and verbal impairment (PICA, Verbal Recognition Test, Naming Test). The correlation analysis as well as subsequent partial correlations and multiple regression analysis, provided strong evidence in support of an "asymbolia" hypothesis as opposed to limb apraxia, or general intellectual deficit. The correlations obtained were all significant and moderate to very high. Two correlations were particularly high, that between the PET and the Manual Apraxia Test which was .70, and between the PET and the PICA, .89 (Duffy, 1987).

Despite the attempt by Duffy and Duffy (1981) to avoid many of the errors and omissions of previous gesture studies, there were a few problems associated with this work. One weakness was the total unrelatedness of the foils on the PRT. The results of Duffy and Watkins' (1984) study, discussed earlier, which was specifically designed to examine this issue, found that response choice relatedness was indeed an important factor in reducing performance on the PRT. Other weaknesses include the fact that etiology was not specified for the brain-injured subjects, and due to the use of the PICA, aphasia subtypes were not delineated. The authors did however state that most of the 47 aphasic subjects were nonfluent and they proposed that future studies be conducted to determine the possible relationship of aphasia subtypes to nonverbal behaviors.

In a long term study of Amer-Ind sign acquisition and use by severe chronic aphasics a student of Robert

Duffy, Carl Coelho (1982), also obtained results that were interpreted as supporting the asymbolia hypothesis. His results indicated that severe aphasics acquire manual signs in terms of imitation, recognition, production, and generalization with varying degrees of success. He was also able to demonstrate a strong relationship between severity of aphasic impairment and degree of success in acquiring signs at all levels of performance.

Although Duffy (Duffy et al., 1975; Duffy & Duffy, 1981; Duffy & McEwen, 1978; Duffy & Liles, 1979) and Pickett (1974) have interpreted their results to support Finkelnburg's asymbolia theory, not everyone who has found high correlations between severity of aphasia and pantomime recognition has interpreted their findings to strongly support asymbolia.

Gainotti and Lemmo (1976) hypothesized that the basic defect seen in aphasia is due to a nonspecific deeply situated central disturbance. Although they proposed two explanations for their findings, asymbolia and disintegration at the semantic level of language, Gainotti and Lemmo (1976) rejected the asymbolia explanation as interesting but lacking in experimental support and favored the semantic disintegration alternative. Thus they postulated that the pantomimed gestures may have been verbally coded by their subjects, and that the aphasic disorder may have impaired this verbal mediation process.

The proposal of an asymbolia explanation for the associated verbal and nonverbal deficits observed among aphasics has raised many questions. Close examination of individual subject's performances in these studies reveals that many of the claims associated with the theory may be unsubstantiated. For example, in Duffy et al., (1975), the range of scores indicates that an impaired performance was not displayed by all of the aphasic subjects. Rather, some of the aphasic subjects made no errors, while some of the right-hemisphere lesioned subjects who exhibited no obvious aphasic symptoms, made many errors. This result was again observed in Duffy and Duffy (1981), although the right-hemisphere damaged subjects here did not perform as poorly as in the earlier study. One theory that has been posited by Christopoulou and Bonvillian (1985) to explain the errorless performance of some of Duffy's aphasics is that "the pantomime recognition tasks employed were not of sufficient difficulty to reveal nonverbal symbol processing deficits across the full range of aphasic subjects; if so, then this failure to find a relationship might be viewed as an artifact of the testing procedure" (p. 5).

Similarly, Gainotti and Lemmo's (1976) data provide little basis for even considering the asymbolia alternative. These investigators used a cut off score (100% correct) that was higher than that received by the poorest performing normal control (90% correct). If the data had been interpreted with a slight change in the cut off score (90% accuracy) 30 of the 53 (57%) aphasic subjects would have scored within the normal range.

The data from the studies presented show that although deficits in gestural behavior are seen among groups of aphasics, the degree of impairment is sometimes relatively small. Based on the weakness of the data used to advance the asymbolia theory some investigators have proposed that there is no necessary relationship between the observed severity of an aphasic disorder and incapacity to understand gestures (Benton, Hamsher, Varney & Spreen, 1983; Alajouanine & Lhermitte, 1964; Christopoulou & Bonvillian, 1985). Other criticisms that have been levied against the central symbolic deficit theory include:

1. The theory's claims are based primarily on group data which limit the type of analysis that can be performed and do not allow evaluation of individual subject's performances (Marshall, 1980).

2. Investigators have focussed their concern on correlating verbal and nonverbal behaviors with isolated levels of aphasia severity without analyzing each subject's linguistic performance carefully (Feyereisen & Seron, 1982). This is especially pertinent since some investigators have found specific aphasia types to be more closely associated with nonverbal impairments. For example, in a study investigating the ability of the different types of aphasics to recognize gestures, Ferro, Santos, Castro-Caldas, and Mariano (1980) observed that gesture recognition was defective more often among the global, Wernicke and transcortical groups than the normal controls and other aphasics (Broca's, conduction and anomic groups).

A fundamental error appears to have been committed by asymbolia advocates when they based their conclusions on pantomime interpretation studies. More recent work using gestures from standardized systems indicates that projected statements regarding aphasics' inability to acquire communicative gestures were premature (Duffy et al., 1975). Evidence for this can be found in the Daniloff, Noll, Fristoe, and Lloyd (1982) study. These investigators examined 15 aphasic subjects on a test of gesture recognition. The subjects were trained using nonverbal procedures to make a pointing response after which a 24-item Amer-Ind Recognition Test (ART) was administered. The subjects were required to select the drawing that was associated with the gesture made by the examiner. The results were as follows: Of a possible 24 correct, 14 of the 15 subjects averaged 22.21 correct. Based on this finding the authors inferred that "although the ability to recognize gestural symbols may not be completely normal in aphasic patients, it is less impaired than recognition of verbal signals" (p. 48). It is important to note that none of the individuals in this study exhibited extreme or profound verbal impairment, therefore, this conclusion may not apply to aphasics with severe verbal impairment. However, in a study discussed earlier where the sign acquisition (Amer-Ind and fabricated signs) skills of twelve severe chronic aphasics were examined, Coelho (1982, 1987) found that such aphasics were able to acquire signs with varying and limited degrees of success. The data also revealed a nonlinear relationship between severity of aphasia and sign acquisition, which was interpreted as suggesting that a critical threshold of severity may exist below which sign training may be ineffective.

The results of the two aforementioned studies suggest that some moderate and severe aphasics may be able to successfully acquire gestures from a standardized gestural system such as Amer-Ind. However, better studies are needed which include a larger number of subjects and comparisons with normal and other nonaphasic brain-injured controls.

The difference in the results obtained by Duffy et al., (1975) employing pantomime recognition versus Daniloff et al., (1982) employing Amer-Ind reflects the importance of evaluating the task and stimuli used in each study. The conflicting results also reflect the various skills and varying degrees of difficulty inherent in different tasks.

The asymbolia hypothesis has had a long history, yet it has not been able to account for all of the data regarding residual gestural abilities of aphasics. Joseph R. Duffy and Robert. J. Duffy, the theory's principle modern advocates, have conducted extensive research to provide experimental support for Finkelnburg's theory, however, their data have not been able to allay the concerns of other investigators who remain skeptical. The major criticisms levied against asymbolia have been that it is too general, and the claims made by its advocates too sweeping and unsubstantiated.

Although other theories have been proposed to explain the gestural deficit seen in aphasia, none, except perhaps Kimura's apraxia hypothesis (Kimura, 1976), have generated as much controversy. As long as the evidence regarding gestural deficits and abilities in aphasics remains contradictory, investigations into the area need to be conducted.

Modality Theory

Proponents of the modality theory consider the gestural deficit seen in aphasia to be due to a breakdown in one of the perceptual modalities i.e. visual, auditory, etc. Aleksandr R. Luria (1973) proposed the neuropsychological framework most closely associated with the modality theory. In this theory a formal distinction is made between receptive gesture and expressive gesture. Within Luria's functional system analysis receptive gesture is regarded as a visuoperceptive phenomenon (Kadish, 1978) that is subserved by the secondary occipital cortex, parietal cortex, and temporo-parieto-occipital brain regions, structures which represent the secondary functional unit (Luria, 1973). Since receptive gesture involves both analytic and synthetic perceptual processes it is believed to depend on both the left and right cerebral hemispheres (Kadish, 1978).

Expressive gestures are defined as manual postures which encode and transmit information unaccompanied by speech (Kadish, 1978). Luria's (1973) analysis conceptualizes expressive gesture as a phenomenon which is subordinate to the demands of goal directedness and symbolic processes. These activities are the function of Luria's third functional unit whose structures are located in the anterior regions of the brain (frontal and prefrontal motor areas). Due to the propositional and temporal nature of expressive gesture the left hemisphere has been identified as important for gesture production.

Examination of aphasic gestural disturbance in terms of a breakdown in specific perceptual modalities has not been a very popular area of study. Nils Varney's early research (Varney, 1978) which found that in aphasics deficits in pantomime recognition were always associated with reading comprehension deficits of at least comparable severity, but not vice versa, has provided the strongest support for the modality theory. Based on his results Varney concluded that the underlying determinant of impaired pantomime recognition had a comparable effect on reading comprehension, its linguistic counterpart mediated in the same modality. It was also concluded that impaired pantomime recognition was symptomatic of a distinct type of aphasic alexia and that "asymbolia" was not a general characteristic of aphasic patients since pantomime was found to be only weakly associated with auditory comprehension and naming ability.

In a later study Varney (1982) investigated the relationship of pantomime recognition to three relevant cognitive performances: Sound recognition, alphabet letter recognition, and the WAIS Block Design Test. The results obtained were similar to those from his earlier study which allowed him to again conclude that aphasic defects in pantomime recognition were not the result of a general "asymbolia" or "loss of abstract attitude". Additionally he concluded that apparently the defects in pantomime recognition result from a specific visual information processing disturbance, "...possibly limited to previously learned associations which are semantically meaningful" (p. 38). He also proposed an interesting explanation for the close relationship between pantomime recognition and reading comprehension, that understanding of gestural communication may have been "preadaptive", in the evolutionary sense, for reading (Varney & Vilensky, 1980).

The findings by Ferro et al., (1980) of a close association between gesture recognition performance and reading in patients with central alexia provide additional evidence to support the modality theory.

Another gestural study that obtained results in support of the modality theory was conducted by Kadish (1978). Gesture and pantomime impairment were examined from a neuropsychological perspective using Luria's theoretical framework for categorizing receptive and expressive gesture. Six aphasic subjects of varying etiology and severity were included in the study, however, there were no controls. Kadish found a significant relationship between speech comprehension and receptive gesture but no relationship between speech production and expressive gesture. It was concluded that receptive gestural ability is closely related to the various perceptual processes which are dependent upon Luria's second functional unit; specifically, visuo-spatial organization and mnestic (memory) processing. Thus, Luria's conception of a common underlying neural substrate for receptive activities received support from Kadish's data.

Although the results regarding expressive gesture and speech did not support any strong conclusions, Kadish offered a possible explanation for the gestural production impairment. It was suggested that such a deficit may be best understood as a breakdown in complex sequential manual motor activity, such as proposed by Kimura (1979).

Seron, Van Der Kaa, Remitz, and Van Der Linden (1979) also demonstrated a modality influence on gestural deficits in their study of pantomime interpretation and aphasia. Their results indicated that pantomime recognition was more strongly correlated with reading comprehension ($\underline{r}$ = .64) than with oral comprehension ($\underline{r}$ = .48). Finally, a recent study conducted by Dr. Paul Rao (1986), investigating Amer-Ind sign comprehension and production by aphasic adults, also obtained results that upheld the modality model. Like Varney (1978), Rao found reading to be the most potent predictor of gestural recognition; additionally, he found praxis to be the most potent predictor of gestural imitation and production.

Finally, in a retrospective analysis of data from an earlier study, Duffy, Duffy, Uryase, and Merritt (1982) obtained results at variance with the modality theory. The specific question addressed by the investigation was: Is the relationship between deficits in pantomime recognition and visual modalities greater than the relationship with nonvisual verbal modalities? Measures of the pantomime recognition deficit and pantomime expression deficit were obtained from 47 aphasic subjects. Correlation coefficients were computed between the Pantomime Recognition (PRT) and Pantomime Expression (PET) measures and various measures of visual (matching, copying, reading, and writing) and nonvisual (speech and auditory comprehension) verbal abilities. Their analyses revealed that the correlations between the PRT and the four visual measures were not significantly greater than either of the correlations between the PRT and the two nonvisual measures. Also, none of the correlations between the PRT and the visual measures were significantly greater than the correlations between the PET and the four visual measures. Therefore, the results did not confirm any special relationship between visual verbal and visual nonverbal deficits in aphasia.

Although the results are interesting they must be interpreted cautiously due to several problems associated with the study. For example, etiology for the aphasics was not well controlled, and the visual and nonvisual tests used in the analysis were not thorough evaluations of the specific language areas but rather subtests taken from the PICA.

Cognitive Theory

The cognitive position on the gestural skills of brain-damaged adults was first articulated by Kurt Goldstein (1948). Goldstein considered the gestural impairment seen in mixed or global aphasia, as part of a cognitive impairment of the "abstract attitude". However, he also recognized that gestures and pantomimes may remain intact in some aphasics, as long as the "abstract attitude" is unimpaired. Another early proponent of the cognitive view was Denny-Brown (1958) who believed that the inability to perform gestures to command was due to a loss of the "conceptual process".

Based on the errors made by aphasic subjects Seron et al., (1979) interpreted their findings of impaired pantomime interpretation in aphasics as due to an intellectual/cognitive impairment. These investigators found that when required to choose from among several pictures associated with a pictured gesture, aphasic's incorrect choices often shared movement and location characteristics versus semantic/lexical similarities. In a similar vein, Paul Rao (1985; 1986) also found that aphasics were more likely to choose motor foils compared to semantic foils on a gesture recognition task. These results serve to point out the importance of examining the conclusions of gestural studies in relation to the tasks and stimuli presented to the brain-damaged subjects.

Anatomical Explanations for Gesture Impairment

Apraxia Theory

Hugo Liepmann (1900/1977) is credited with establishing the neuropsychological theory stating that the gestural disturbance seen in aphasia is due to destruction of anatomical structures in the left hemisphere related to control of skilled movement. He proposed the term motor apraxia to describe disorders of learned skilled movement not caused by poor comprehension, motor or sensory defects, or intellectual deterioration (Liepmann, 1900/1977). Liepmann viewed apraxia as an independent neuropsychological disorder and considered the various types of apraxia as due to disturbance at one of several possible levels of the same basic praxis mechanism. Although Liepmann believed that the memory for a complex motor act could not simply be localized to a circumscribed cortical area, he was responsible for relating the different types of apraxias to damage in specific cortical areas (Hecaen & Albert, 1978). The region he considered most critical for praxic control was the left supramarginal gyrus.

Goodglass and Kaplan's study (1963) was the first "gestural study of brain-injured adults that supported Liepmann's apraxia theory, including his interpretation that aphasia and apraxia are independent disorders linked only by the contiguity of their anatomical structures. Because of the results Goodglass and Kaplan (1963) acknowledged that the gestural deficiency seen in aphasia could <u>not</u> be part of a " common psychological factor". They proposed instead that their results supported Liepmann's concept that aphasia and apraxia are independent disorders and the gestural impairment indicates a separate apraxic disorder.

The last two studies to be presented describe patients exhibiting unusual cerebral organization of praxis and language. The first study was conducted by Kertesz and Ferro (1984) who, as part of a large study on the association of lesion size and apraxia, reported on 16 patients with computerized tomography (CT) evidence of left hemisphere stroke who exhibited severe aphasia and spared praxis. The sparing of praxis suggested to the investigators bilateral representation of visuokinesthetic motor patterns and functionally active right parietofrontal connections. This conclusion was based on the finding of uncommon patterns of skull asymmetries which the authors postulated may have been related to bilateral distribution of function. The second investigation conducted by Selnes, Rubens, Risse and Levy (1982) reported on a case of mixed cerebral dominance for language. Their patient was a 58-year-old right-handed man who became aphasic following a left-hemisphere stroke. Despite the massive size of the lesion his aphasia was only transient. In the acute period he presented with a bilateral ideomotor apraxia and agraphia which persisted for three years following initial onset. These two studies showing how aphasia and apraxia can be differentially affected by circumscribed brain damage provide strong evidence in support of Liepmann's theory that aphasia and apraxia are independent disorders.

Some recent anatomic investigations of apraxia, using CT evidence acquired from large numbers of stroke patients, have raised some serious questions regarding the anatomic proximity thesis and Liepmann's long supported claim that the parietal cortex was important in praxis. Basso, Luzzatti and Spinnler (1980) evaluated computerized axial tomography (CAT) scans recorded from 123 patients with left hemisphere damage from stroke. The patients were divided into four experimental groups according to the presence or absence of ideomotor apraxia and length of illness. The investigators could not find any difference in lesion sites between patients with and without ideomotor apraxia except for a higher frequency of deep lesions in the nonapraxics. A later study conducted by Kertesz and Ferro (1984) reported findings at variance with Basso et al., (1980). The CT scans of 177 adult right-handed left-hemisphere stroke patients were examined for site of lesion and evaluated in relation to performance on an apraxia test. Kertesz and Ferro (1984) found lesion size to be positively correlated with aphasia severity, although not all patients presenting with ideomotor apraxia had large lesions. These authors also found that only some of the small lesions producing ideomotor apraxia involved the parietal lobe, specifically the angular gyrus and surrounding areas. Rather in their patients the most frequent location of small lesions producing apraxia was in the anterior half of the periventricular white matter. The specific lesions identified with apraxia were found in the deep parieto- and occipitofrontal and anterior callosal fibers. There were also patients with large lesions who did not exhibit apraxia. As in the Kertesz and Hooper (1982) study, Kertesz and Ferro (1984) attributed this negative finding to atypical skull asymmetries suggesting a right hemisphere role in sparing and recovery of praxis.

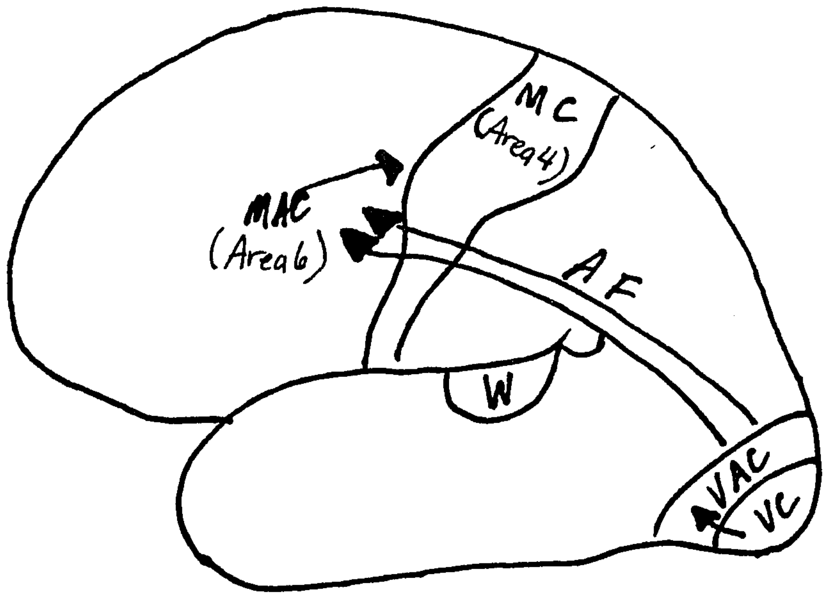
Elaborations on Liepmann's Model

Elaborations on Liepmann's model have been presented by Norman Geschwind (Benson & Geschwind, 1971; Geschwind, 1975) and Kenneth Heilman (1979; Heilman, Rothi & Valenstein, 1982).

Geschwind. Geschwind (1975) proposed that the left hemisphere is dominant not only for speech but also for learned movements. Geschwind has based his view of ideomotor apraxia on a disconnection model (see Figure 1). The schema is as follows: When a patient with a dominant left hemisphere is given a verbal command to make a movement with his left hand, it is first registered in the left Wernicke's area. The stimulus is then projected to the motor association cortex of the dominant hemisphere via the arcuate fasciculus. From the motor association cortex the neural impulse moves across the corpus callosum to the motor association cortex on the right side, and then to the motor cortex, which is responsible for innervation of specific body parts.

As can be seen from the above discussion the parietal lobe plays little role in Geschwind's schema. Geschwind's model instead, emphasizes the involvement of the pyramidal tract and Wernicke's area. In Geschwind's design there are three possible areas where disconnection can occur each leading to a different variety of ideomotor apraxia. Damage localized to Wernicke's area interferes with comprehension of verbal

Figure 1. Geschwind's schema (Geschwind, 1975). Lateral view of left side of brain. AF = arcuate fasciculus, MAC = motor association cortex, MC = motor cortex, VAC = visual association cortex, VC = visual cortex. The arrows indicate major connections of the areas shown.


MC
(Area 4)
MAC
(Area 6)
A F
W
VAC
VC

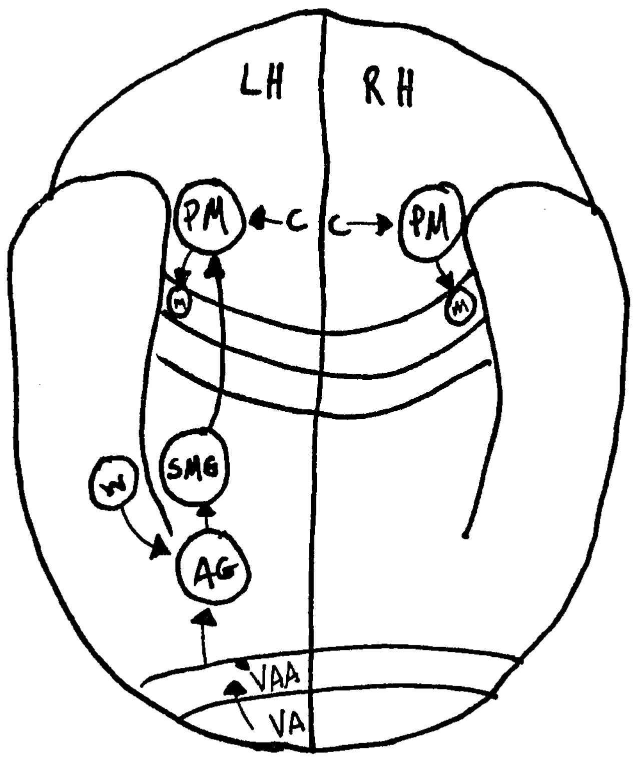
commands. Therefore, the patient, although unable to carry out verbal commands, will correctly imitate movements.

Disconnection occurring further down in the arcuate fasciculus allows comprehension of the spoken command, but interferes with the ability to carry out the command, thus these patients will not improve significantly on imitation. Lesions of the dominant motor association cortex usually involve the adjacent motor cortex which causes hemiplegia in the contralateral limb. The limb innervated by the opposite hemisphere will also perform poorly to verbal command. This is the disorder "sympathetic apraxia", first described by Liepmann (Kimura,1980). Another disorder first described by Liepmann (Kimura,1980) occurs when there is a lesion of the anterior corpus callosum, or callosal fibers deep in the white matter of either frontal lobe. In this case the patient can carry out commands with the dominant limbs but not with the limbs of the other side.

Thus, Geschwind's disconnection theory attempts to account for the various types of ideomotor apraxia on the basis of disconnection of the areas in which the command is comprehended from those areas where the command is carried out. Geschwind realized, however, that the disconnection approach could not account for all of the phenomenon observed among apraxics. In a later paper he (Geschwind, 1975) proposed an explanation for why many apraxic patients fail to improve on imitation or when presented with the object associated with a movement. The theory is based on Liepmann's suggestion that the hemisphere dominant for handedness is also a repository for the learning involved in the acquisition of motor skills (Kimura, 1980). Geschwind proposed that the left hand exhibits reduced motor skills resulting in impaired imitation because much of its skill is borrowed from the left hemisphere across the corpus callosum.

Heilman. Heilman (1979) suggested an alternative to Geschwind's hypothesis (see Figure 2). According to Heilman's theory, when an individual is required to perform a skilled act to command, imitation or to use objects skillfully, the idea of the movement projects from the speech areas to the parietal lobe where visuokinesthetic motor engrams are located. These engrams then program a sequence of movements and each of the movements in turn is programmed in the motor association cortex. The motor association cortex then

Figure 2. Heilman's schema (Heilman, 1979). View from top of brain. W = Wernicke's area, VA = primary visual area, VAA = visual association area, AG = angular gyrus, SMG = supramarginal gyrus, PM = premotor area (motor association cortex), M = motor cortex, CC = corpus callosum, LH = left hemisphere, RH = right hemisphere. The arrows indicate major connections of the areas shown.


LH
RH
PM
C
C
PM
M
M
SMG
W
AG
VAA
VA

coordinates activation and inhibition of different motor neuron pools via the motor cortex.

Based on their research Heilman et al., (1982) have identified two separate forms of ideomotor apraxia which can result from destruction of specific structures in the proposed system. One form of apraxia results from lesions of the supramarginal or angular gyrus. The patients perform poorly to command and imitation, and also cannot discriminate poorly performed from well performed acts. The other form results from lesions anterior to the supramarginal gyrus that disconnect the visuokinesthetic motor engram from the premotor and motor areas important in programming movements. Patients with this disconnection form of ideomotor apraxia cannot perform well to command or imitation, but can discriminate between well-performed and poorly performed acts. Heilman (1979) notes that "when a patient with ideomotor apraxia performs poorly he does not make an inappropiate movement, rather his movements are correct in intent but they are clumsy" (p. 174). He continues "since a patient with ideomotor apraxia does not perform inappropiate acts it is not surprising that he can recognize inappropiate acts" (p. 174).

Heilman et al. (1982) postulate that the reason why the patients with supramarginal or angular gyrus lesions are unable to perform and recognize well-performed acts is that the posterior lesions destroy the visuokinesthetic motor engrams. It is also proposed that patients able to correctly use objects and perform to command but who are unable to imitate or recognize gestures, may have a disconnection between the visual areas and the visuokinesthetic motor engrams.

Kimura. Another view of the relationship between apraxia and aphasia stems from Doreen Kimura's hypothesis that the left hemisphere is specialized for the selection and production of complex motor sequences "which happen to lend themselves readily to communication " (Kimura, 1976, p. 145). Kimura has supported her position by noting the frequent association of limb apraxias with aphasia following left hemisphere lesions (Kimura, 1976). Kimura has four basic arguments to support her claim: (a) the association between hand preference and speech lateralization in the brain, (b) the frequent association of hand movements with speaking in normals (Kimura, 1973), (c) the frequent association of apraxic disorders with left hemisphere lesions (Kimura & Archibald, 1974), (d) the association of disorders of manual communication in the deaf with left hemisphere damage (Kimura, 1981).

According to Kimura (1979) both manual and vocal communication involve a series of complex self-generated movements, which appear to depend minimally, if at all, on sensory feedback. Rather both forms of communication depend critically on the left hemisphere of the brain for normal functioning. Kimura has postulated that the left hemisphere contains a "praxic" system which seems to be especially important for the selection and execution of a new posture, but once a posture is achieved, it can run off repeatedly without the intervention of this system. This was evidenced on a simple task like repetitive finger tapping (Kimura, 1977) as well as a more complex repetitive movement such as the Screw Rotation task (Kimura, 1979).

Kimura has identified the left posterior perisylvian region as critical for control of praxic movements (Kimura, 1979). This posterior praxis system is believed to exercise control over both hands, and the oral musculature when complex postural changes must be produced.

Further evidence for Kimura's posterior praxis system comes from her finding (Kimura, 1979) "...that the degree of apraxia is, if anything, more highly correlated with "receptive" aphasia scores than with "expressive" scores, suggesting a more posterior locus for praxic control" (Kimura, 1979, p. 214). She has also observed that although manual apraxia can occur from left frontal lesions, it appears to be generally less severe after frontal than after posterior damage (Kimura, 1979).

In contrast to sequential movements, production of single movements (static postures), whether verbal or nonverbal, is associated with a more anterior system on the left (Kimura, 1979; Kimura, 1982). Kimura did not laterlize static hand postures, however, based on her investigations of the effects of anterior lesions (Kimura, 1982), it might be assumed that both oral and manual static postures may be mediated by the same left anterior system.

Kimura's theoretical framework has been supported by two separate studies. The first investigation was conducted by Kolb and Milner (1981) who examined the performance of complex arm and facial movements after focal brain lesions. Patients with unilateral removals from the left or right frontal, central, temporal, or parietal regions and normal control subjects were asked to copy complex movements of the arm or face. The movements were intended to be meaningless. Left parietal lobe lesions were found to impair the performance of arm movements, with a milder impairment observed following lesions of either frontal lobe. In contrast, the patients with left parietal lobe lesions were not impaired in the imitation of facial movement sequences. Lesions elsewhere in either hemisphere did not affect performance on either the arm or face task. In this patient population, which contained few aphasics, no relationship was found between aphasia and movement-copying deficits.

Additional data supporting Kimura's theoretical design comes from her own laboratory (Kimura, 1982). Several tasks requiring oral and manual movements were presented for reproduction to patients with unilateral restricted lesions of the right and left hemisphere. Patients with frontal and parietal left hemisphere lesions exhibited the most severe impairment on both the manual and oral tasks. The left frontal area was found to be most important in the control of oral movements, and the parietal lobe in control of hand movements, however, both regions were required for the more complex oral and manual tasks. Separability of the oral and manual control systems was found to be greatest in the frontal than in the parietal region, meaning that the left parietal lobe appeared to be much more important for producing oral movements in addition to manual movements, than the left anterior region was for the production of manual movements in addition to oral movements.

In a review of 11 cases of manual signing disorders in the deaf, following left-hemisphere brain damage, Kimura (1981) reported that in right handers disorders in production and comprehension of manual signs clearly occur from left-hemisphere damage; while in left handers sign impairment is associated with left- or right-hemisphere damage. The pattern of errors produced in manual signing following left-hemisphere damage was also very similar to that seen in speech aphasia. Further, it appears that within the left hemisphere posterior damage may be sufficient to produce a manual signing disorder. The thrust of Kimura's argument is that the signing disorders observed in deaf brain-damaged individuals are the result of a manual apraxia, which is characterized by a motor selection deficit that is not language based. One observation that is presented in support of the manual apraxia argument is that writing is typically affected in association with manual signing disorders, while reading is relatively unaffected. This observation is particularly compelling because reading is not syllabically based in deaf as it is in hearing individuals.

Included in Kimura's unique conception of the "praxic" system is the suggestion that there may be several, presently unknown, complementary systems in praxic control, and that such control may not depend exclusively on cortico-cortical or callosal pathways (Kimura, 1979). Kimura (1979) speculates that the bilateral control mechanism may conceivably operate via basal ganglia pathways, and/or other subcortical structures including the thalamus.

Kimura's conceptualization of aphasia has not received strong support. One severe critic of Kimura's position is Marshall (1980). Marshall's criticism is based on the idea that in Kimura's model aphasias are reduced to movement disorders. Such a view of aphasia is considered detrimental by Marshall because it serves to deny that there are any principles unique to the language faculty; to deny, as it were, that there is a language faculty. Finally, based on the reported dissociations of vocabulary types found between some cases of Broca's and Wernicke's aphasia, and of paraphasic disturbances across the modalities of speech and writing, Marshall finds Kimura's sensorimotor explanation of aphasia difficult to support "unless one loosens the hypothesis to the point of vacuity" (Marshall, 1980. p. 282).

Although Kimura's view has been strongly criticized, her suggestion that there may be alternate anatomical pathways capable of subserving the praxis system, remains an intriguing area for further investigation.

Gesture Impairment in Aphasia: Critique of the Theories

To date no single theory or model has been able to adequately explain the complex issue of the gestural deficit seen in aphasia. The asymbolia framework has been criticized for being too broad and making unsubstantiated sweeping claims, such as, that symbolic movements should be less well interpreted than abstract movements. On the other hand Kimura's apraxia concept has been labeled as simplistic because it reduces aphasia to a general movement disorder without taking into account receptive gestural deficits. Both theories have been criticized for viewing language in such a narrow manner that the principles considered unique to the language faculty have been practically ignored. However, despite all the criticism the asymbolia theory is the one with the largest number of supporters and the one gaining in popularity presently. Also despite the fact that their data may not have completely supported asymbolia few investigators have been willing to totally discount it as an alternative explanation for their results (Kadish, 1978; Gainotti & Lemmo, 1976). Marshall also warns that it would be a mistake, to assume that language and gesture are unrelated. After all, in association with language, humans produce many movements that serve to accentuate and color their communication; and these movements are produced appropriately in the context of the situation. Clearly there must be some central mechanism that coordinates both body and language. An interesting study conducted by Cicone, Wapner, Foldi, Zurif, and Gardner (1979) analyzed short conversation samples from two anterior (Broca's) aphasics and two posterior (Wernicke's) aphasics). The observations revealed that gesture production paralleled speech production both quantitatively and qualitatively. Thus, the Broca's aphasics produced relatively few gestures per unit time, which were reasonably clear and informative. The Wernicke's aphasics used more gestures and their gestures were more complex, noniconic, vague and general. Further analysis of the two Wernicke's subjects data (Delis, Foldi, Hamby, Gardner, & Zurif, 1979) revealed that they were more likely to gesture at the initial boundary of an embedded clause when there was semantic discontinuity between the main and subordinate clause. A more recent study conducted by Duffy, Duffy, and Mercaitis (1984; Duffy, 1987), comparing the pantomimic performance of a fluent and nonfluent aphasic, obtained similar results. Fluent subjects were observed to produce significantly more gestures than normal controls, and nonfluents significantly less. Additionally the pantomime of the fluent subject appeared tangential and circumlocutious, while the responses of the nonfluent subject were often delayed, brief, unelaborated, and effortful. These studies on spontaneous gestural production reveal that both speech and language reflect the patient's general communicative "style".

With respect to the neural basis of gesture recognition most experts identify the dominant hemisphere parietal lobe as essential for the recognition function. Some of the exceptions are Kadish (1978) and Poizner and Lane (1979). Kadish includes the left hemisphere occipital cortex, the temporo-parieto-occipital structures, and the right hemisphere, as well as the parietal cortex in her formulation. Poizner and Lane (1979) found that for both deaf and hearing adults static signs appear to be processed by the right hemisphere and kinetic signs (Poizner, Battison, & Lane, 1979), examined only among deaf subjects, were not clearly lateralized.

Due to the various situations (imitation, movement to command, object use, communicative use) in which expressive gesture can be elicited, no single lesion site has been identified for that function. Most investigators have concluded that the left posterior parietal zone is important for communicative gesture. The other types of expressive gestural behavior may be explained by Geschwind's disconnection model (Geschwind, 1975), Luria's (Luria, 1973) dynamic functional system approach, or Kimura's subcortical conceptualization. What is clear is that there are several forms of movement disorder and the neurological framework to account for all of them has yet to be delineated. Although the left hemisphere has been identified as important for kinetic and complex movements (Kimura, 1979), neither hemisphere has been specifically implicated in the control of static hand postures (De Renzi et al., 1980) or repetitive movements (Kimura, 1977, 1979).

Since none of the current neuropsychological theories proposed to explain the gestural deficit observed among aphasics have been able to adequately handle the variety of gestural impairments, in addition to not being universally embraced, perhaps the time has arrived to consider one more alternative. Hecaen (1978) has presented an interesting idea in his proposal that an underlying neuropsychological deficit, such as defective sensory guidance of fine motor behavior, might represent a necessary, if not sufficient condition for apraxia. In addition, the combination of such a disorder, which he refers to as "prepraxic", with a specific hemispheric location could perhaps explain the various manifestations of apraxia. It is hoped that Hecaen's suggestion may serve to stimulate future investigations into the complex disorder of apraxia which, it is clear, has yet to be fully explained.

Gestural Systems Used in Aphasia Rehabilitation

In the last fifteen years there has been great interest in training severely aphasic patients to communicate using gestural methods. Glass, Gazzaniga, and Premack (1973) conducted one of the earliest studies to report the successful use of an artificial language training program in global aphasics with no "functional expressive capacities" (p. 96). They trained seven global aphasics with severe expressive language impairment to use Premack symbols (cut out paper symbols of varying color, size, and shape) as the functional equivalent of words. These symbols were used to express understanding of various semantic principles (i.e., same-different, negation, etc.). Various levels of competence were attained among the seven subjects suggesting "...that rather sophisticated and abstract symbolic thought can be carried out in patients having been rendered essentially languageless..." (Glass et al., 1973, p.102). The Visual Communication system (VIC) developed by Gardner, Zurif, Berry, and Baker (1976), has also revealed that some cognitive operations are preserved even in certain severely impaired aphasics. VIC is a technique in which the patient uses an index card system of arbitrary symbols to represent syntactic and lexical components. The patients then manipulate the symbols to respond to commands, answer questions, describe actions, and may even progress beyond the basic level to express their own wants and feelings.

A gestural alternative to VIC, Visual Action Therapy (VAT), has been developed by Helm-Estabrooks, Fitzpatrick, and Barressi (1982). VAT is a hierarchically structured three level program that relies heavily on visual cues, and ultimately trains patients to produce symbolic gestures for visually absent stimuli through the manipulation of real objects. Helm-Estabrooks et al., administered VAT to eight global aphasics and reported posttraining results indicating significant improvement by these patients in their performance on FICA subtests which measure pantomime and auditory comprehension. These results indicate that even severe aphasics can learn to recognize and produce distinct pantomimes in association with specific objects.

Although use of artificial communication methods such as chips or picture symbols in aphasia rehabilitation has resulted in reports of some limited success, a major problem associated with their acquisition is the inability of subjects to generalize their use beyond the training situation. As an alternative to these artificial modes clinicians have recently become interested in training aphasics to communicate using gestural methods. With the current interest in gestural communication it is unfortunate that very few studies have actually investigated its efficacy with aphasic subjects. The lack of published studies is probably due to both the many requirements for undertaking training programs in general, such as: (a) motivation of patients, (b) family support, and (c) the need to plan for a large number of training sessions; as well as the problems specific to gesture studies which include: (a) skepticism on the part of patient's families regarding the universality of gestures, and (b) lack of knowledge on the part of patients regarding the potential of gestures to convey ideas. Those studies that have been conducted generally have been exploratory in nature, and have not included systematic examinations of the efficacy of different training procedures. Most important, descriptions of subject's language and motor impairments prior to training have been severely lacking, thus providing insufficient information from which to establish firm conclusions.

In the following sections the various gestural methods currently being used to facilitate communication in severe aphasics will be described followed by a discussion of gestural training programs. Particular emphasis will be placed on those programs that have trained aphasics to communicate using Amer-Ind Gestural Code and American Sign Language (ASL) vocabulary signs. The reason for this focus is that both ASL and Amer-Ind have been shown to be good facilitators of language in severly language impaired individuals (Musselwhite & St. Louis, 1982).

Non-language gestural systems

Pantomime. According to Disimoni (1981) "pantomime may be conceptualized as the propositional use of nonverbal motor behavior, including the body and facial expressions, in order to convey specific messages" (p. 340). Silverman (1980) has identified several major differences between pantomime, and other gestural systems, such as ASL or Amer-Ind:

1. It uses the musculature of the entire body, not only that (or primarily that) of the upper extremities;

2. The gestures tend to be kinetic rather than static;

3. More gestures usually are needed to convey a message than with the manual systems;

4. The gestures are an analogue of the message-that is, they are a dramatization of the message (p.72).

Musselwhite and St. Louis (1982) have also noted another difference between pantomime and other gestural methods, that is, because pantomime is truly concept based, events and objects can be represented in a variety of ways. In contrast conveying concepts using ASL or Amer-Ind involves using specific gestures where the ease of perceiving a relationship between each gesture and its referent varies among the gestures.

<u>Limited hospital or center-based systems</u>. Limited gestural systems are sometimes developed for use in facilities serving language impaired individuals. They are generally developed by the staff to facilitate communication of basic needs. The number of gestures

included in such systems tends to be limited, which also serves to make these systems easy to acquire. Typically, the systems require only moderate control of one hand (Musselwhite & St. Louis, 1982). The disadvantage of such systems is their limited range of use.

Adapted fingerspelling. Fingerspelling is a gestural language code which uses 26 distinct handshapes to represent the 26 letters of the Roman alphabet. When compared to speech and manual signing, fingerspelling is relatively slow. Since fingerspelling requires good motoric control in order to properly execute each posture, and the ability to spell, it is not commonly the method of choice with aphasic patients.

Amer-Ind Gestural Code. Amer-Ind is a gestural system based on universal American Indian Hand Talk, which was used by a variety of Indian tribes to accommodate their large number of spoken languages (Skelly, 1979). The current clinically tested signal repertoire includes 250 concept labels. Eighty percent of the signal repertoire can be executed using only one hand, and most of the remainder can be adapted for one-handed execution using suggestions provided by Skelly (1979). For the 11 signs which cannot be adequately adapted Skelly (1979) suggests that other signals or a string of signals be used. Amer-Ind is composed of signs which are concrete representations of the characteristics of the objects, actions or persons being referred to. Amer-Ind is not considered a language in the true sense because rather than an arbitrary relationship existing between the symbols and their referents, the relationship is clearly a direct representational one. It has been demonstrated that interested and motivated viewers can interpret Amer-Ind signs at an 88% level of comprehension without any prior instruction (Skelly, 1979).

Amer-Ind was first described as a gestural communication system for the speechless by Skelly et al., in 1974 and has become widely used by clinicians over the years. The reasons proposed to explain why this system has become so attractive for use with severe aphasics (Skelly, 1979) include Amer-Ind's low symbolic level, ease of acquisition, flexibility, speed of transmission, lack of grammatical structure, and use of concrete demonstrable referents which enable interpretation with minimal training. Additionally, a recent study by Daniloff and Vergara (1984) has found that the production requirements of Amer-Ind signals are less motorically demanding than those for ASL signs.

Paget-Gorman Systematic Sign. Paget-Gorman Systematic Sign was developed by Sir Richard Paget (1951, cited in Musselwhite & St. Louis, 1982) in England and was the first English based educational sign system. This system does not use English morphological structures or ASL signs. Paget-Gorman Systematic Sign is based on pantomimic signs which include combinations of 21 standard hand positions and 39 basic signs. The basic signs serve to group signs with a common concept such as FOOD and ANIMAL, while the hand configurations indicate specific entries within each group (Musselwhite & St. Louis, 1982). Signs are formed by combining the basic signs with the standard hand configurations. It is believed that this system of sign and mime allows not only for the development of an extensive vocabulary, but the production of grammatical sentences as well (Disimoni, 1981).

Makaton Vocabulary. The Makaton Vocabulary is a nine stage system of signs that is based on the British Sign Language of the Deaf (Stuart-Smith & Wilks, 1979). The signs of this system can be performed with either hand often making it possible for physically handicapped persons to adapt the signs without loss of meaning. Fine manual dexterity is needed to differentiate between many of the signs.

Sign Languages: American Sign Language

The history of American Sign Language is reported to have begun in France in 1750 when a priest, Michael L'Epee, interested in providing education for poor deaf children, developed a new approach to deaf education (Klima & Bellugi, 1979; Stokoe, 1960; Lane, 1976). L'Epee's method included combining the signs used by his deaf pupils to converse among themselves with additional adapted or invented signs (Klima & Bellugi, 1979). The sign language developed by L'Epee was them brought back to the United States by an American, Thomas Gallaudet, and he along with Laurent Clerc implemented this method of instruction at the American School for the Deaf in Hartford, Connecticut (Klima & Bellugi, 1979).

American Sign Language (ASL) is the language most of the deaf in this country use to communicate. This language, which is not based on English, has its own process of word formation, and its own methods of expressing meaning by incorporating basic units. These basic units, called signs, are incorporated into sign phrases to express variations in meaning. American Sign Language is a self contained, largely arbitrary system that is not universally understood. For example, British deaf individuals use a sign language that is very different from ASL, although the written language in the two countries is the same. This is quite understandable since ASL is descended from a lineage very separate from the oral language tradition of English, mainly an older form of French Sign Language (Peng, 1978). Since ASL is a language and not merely a code to represent English or any other language, there is often not a one-to-one correspondence between ASL signs and any other spoken language.

When deaf people communicate among themselves the "signing" is often interspersed with elements of pantomime. However, signers do make a distinction between what is clearly signing and what is clearly pantomiming. There are conditions of "well formedness" in ASL, which means that particular handshapes are required and different renditions of ASL signs are recognizable across all signers. The distinction between pantomime and sign is that pantomime depends on effective picturing of the concept and sign is the acceptable rendering of the inherent form of the sign. Pantomime allows body movement as well as use of all the space within reach of the arms (Klima & Bellugi, 1979). Signs are restricted to the hands alone and to well specified handshapes, locations, and movements within a limited signing space.

Signs have traditionally been described as transparent. Transparency is defined as the extent to which a sign's meaning can be understood from its form alone (Klima & Bellugi, 1979). Studies conducted to determine ASL sign transparency have found that hearing subjects, with no prior knowledge of sign language, have difficulty identifying the correct meaning of signs (Klima & Bellugi, 1979). The results of these studies have indicated that only about 10 percent of ASL signs are transparent. These findings serve to verify that ASL signs are not merely representations of concepts but rather a limited set of handshapes that correspond to formational values.

Based on several analyses of ASL signs four parameters have been identified as essential for the construction of an individual ASL sign (Lane, 1976; Stokoe, Casterline, & Croneberg, 1976; Baker & Padden, 1978; Bellugi & Klima, 1979; Battison, 1980). These parameters include:

1. Tabula (tab), the location (LOC) on the body, or in space, where the sign begins and ends, also referred to as the place of articulation (example: cheek).

2. Designator (dez), the distinctive handshape(s) (HS) or configuration(s) used to make the sign (example: fist).

3. Signation (sig), the movement (MOV) of the hand or hands when producing the sign (example: up-and-down).

4. Orientation, the direction in which the palm of the hand(s) face (example: palm up). This parameter will be referred to in the text as PO.

William Stokoe developed a classification scheme for ASL signs which is presented in the Dictionary of American Sign Language (DASL) (Stokoe, Casterline, Croneberg, 1976). According to Stokoe's analysis there are 19 classes of hand configurations, 12 places of articulation, and 24 different types of movement which can occur singly, in sequence, or simultaneously within a single sign (Klima & Bellugi, 1979). Each of the four parameters can illustrate minimal contrasts. For example, the signs home, flower, and peach, are all formed with the same handshape, however each of these signs differs from the other by either the location, movement or orientation of the hand.

In addition to the hands ASL takes advantage of the special abilities of the human body and the human eye to increase its efficiency of conveying information (Baker & Padden, 1978). The face serves an important role in sign transmission due to its ability to express shades of meaning.

Musselwhite and St. Louis (1982) list several skills that they feel a candidate for ASL training should possess or be expected to acquire:

1. Good motor control of both hands.

2. Good range of motion with both arms.

3. Good control over facial musculature.

4. Good visual acuity and visual discrimination.

5. Sensorimotor stage 5 or 6 intelligence.

(p. 100-101)

Characteristics of ASL signs fall into three categories: (a) phonological parameters i.e., the basic building blocks of signs; (b) motoric factors i.e., features associated with the movements involved in making a sign; (c) conceptual features i.e., semantic information conveyed by sign referents. In this section studies relevant to the characteristics associated with each of the three categories will be examined. The discussion will address both theoretical and clinical issues. The theoretical focus will be the specific characteristics that influence acquisition of ASL signs. The clinical focus will be the characteristics most facilitative of sign learning by severely language impaired individuals.

Phonological parameters. Signs are constructed by the simultaneous combination of the four previously described parameters of LOC, HS, MOV, and PO. Each parameter can assume a limited set of values alternately referred to as cheremes (Stokoe, 1960) or primes (Klima & Bellugi, 1979). Although these four parameters typically occur simultaneously in the production of an individual sign, they have also been examined to determine their singular contribution to sign acquisition and retention. The primary concern has been whether or not a hierarchical order of difficulty in acquisition or retention can be assigned to the parameters and whether or not similar hierarchies can be established within each parameter (Doherty, 1985).

Research conducted by Wilbur and Jones (1974) on the acquisition of simple, single signs by three hearing children of deaf parents suggest the following order of acquisition for the phonological parameters: location, movement, handshape. This sequence has also been observed in the acquisition of sign classifiers among deaf children of deaf parents (Kantor, 1980). Additionally, the children in Kantor's study exhibited mastery of orientation simultaneously with that of handshape during the final stage of acquisition. Therefore, based on observations of the acquisition of signs by deaf children of deaf parents, the phonological parameters may be ordered from least to most difficult to acquire as follows: location, movement, handshape combined with orientation. Support for this hierarchy of acquisition for ASL parameters also comes from a study where productive acquisition of ASL signs by deaf mentally retarded individuals was examined (Doherty, 1985). The subjects received their sign instruction in a training environment rather than by interacting with deaf signers. When compared to novice severely and profoundly retarded learners, experienced moderately retarded learners made fewer phonological/cheremic errors, however, the pattern of errors was the same for both groups. Production errors were greatest on HS cheremes, than on MOV cheremes, and least on LOC cheremes. In summary, it appears that for deaf and hearing subjects in a deaf environment, phonological sign parameters are acquired in the following order: LOC, MOV, HS. Further studies are needed in order to verify this as the sequence of acquisition of sign parameters.

Support for the sequence as indicative of the hierarchy of importance for each of the sign parameters comes from a study conducted to determine the effects of sign simplification (Bornstein & Jordan, 1982 cited in Doherty, 1985).

The subjects were deaf college students who were required to indicate the meanings of 324 basic signs when: (a) location was eliminated by showing hands without the head or body; (b) handshape was held constant by the use of formless mittens on the hands; or (c) movement was eliminated by fixing the hands in the position corresponding to the center of movement. Correct Identification of 65% of the signs was achieved by the majority of the students (greater than 50%) when location information was eliminated, 52% correct identification was achieved with movement eliminated, and only 42% of the signs were correctly identified when handshape was eliminated. It can be inferred that in addition to eliminating handshape information the mittened hands also resulted in removal of orientation cues, therefore, the identification results obtained for handshape probably simultaneously indicate the relative importance of orientation in the hierarchy. Hence, the most important parameters for identification, handshape and orientation, are the most difficult to acquire, followed by movement, and the least important for identification, therefore least difficult to acquire, is location. Based on these results it can be concluded that "...the relative importance of the four parameters to sign identification parallels exactly their hierarchical order of initial acquisition" (Doherty, 1985, p. 4).

In order to ascertain whether there is a hierarchical ordering in memory for the major formational parameters among deaf signers, and if so what the relative importance of the parameters is, Bellugi and Klima (1979) conducted a study in which each of the parameters and primes within parameters were held constant. The investigators constructed a total of 18 lists with five signs. The 18 lists were divided into three groups each group containing six lists each. The signs in each group of six lists shared one particular formational parameter (either HS, PA (place of articulation = LOC), or MOV), while the other two parameters were varied. Immediate serial recall of these lists was compared to that of lists dissimilar on all three parameters. Results indicated that of the three major parameters, only similarity in LOC produced a decrement in recall. Similarity of MOV seemed not to affect recall in a consistent way; similarity of HS enhanced recall.

Klima and Bellugi (1979) further examined possible reasons for the difference in recall. A group of hearing people unfamiliar with ASL were asked to rate the similar-form lists for degree of shared similarity among signs. It was found that similarity in MOV was less salient than similarity in HS or in LOC. Klima and Bellugi (1979) concluded that the saliency of HS and LOC may be explained as follows: (a) Handshape may be stored as a property of the entire list and function in recall to provide a strategy for choosing alternatives, and (b) location may well be the key information associated with the serial position of remembered items.

The hierarchical ordering in memory among the major parameters of ASL signs (i.e., HS, MOV, LOC) is thus the reverse of the order found for their ease of acquisition and their importance to sign comprehension (i.e., LOC, MOV, HS plus OR). Doherty (1985) examined the processing demands of serial recall versus acquisition and comprehension, and proposed an interesting explanation for why the reciprocal nature of the two hierarchies is consistent rather than contradictory. According to Doherty use of locational differences among signs would allow maximal spatial distinctions to be made between signs, which then could serve as convenient memory pegs for them. The distinctions between signs would be based on easily observed gross-motor differences that would reduce encoding demands and thereby increase time available for rehearsal, facilitating sign acquisition and comprehension. Following Doherty's line of reasoning one could speculate that when location is held constant, due to its saliency for sign differentiation, there is a reduction in the observable differences between signs resulting in an increase in confusion and a subsequent reduction in recall. In explaining why the HS feature impedes acquisition and comprehension Doherty (1985) states that "conversely, handshape differences allow only minimal spatial differentiations that would function poorly as memory pegs and that would concomitantly increase encoding demands because of the necessity of more complex fine-motor discriminations among items" (pp. 6-7). Doherty (1985) adds that "holding handshape constant enhances recall because it greatly reduces the encoding demands through redundancy, thereby increasing time available for rehersal" (p. 7).

The consistent hierarchical order of parameters that has been identified for deaf signers and found to apply to hearing signers of deaf parents, has not been verified for hearing signers who acquired ASL as a second language. Crittenden (1974) administered a receptive sign identification task to two groups of hearing college students after they had completed an introductory sign course. Analysis of the confusion errors made by the two groups of subjects revealed that signs differing in action/direction of movement were confused most frequently, followed by those differing in handshape, and the least frequently confused signs were those differing in location. Movement, handshape and combined movement/handshape confusions accounted for 60 to 80% of all errors made by subjects in the two groups analyzed. Hence it can be tentatively concluded that for novice non-brain-damaged individuals decoding ASL signs, the hierarchical order of parameters is LOC, HS, and MOV. Interestingly, the results contrast with those of deaf signers. Hearing signers experience more difficulty perceiving and producing movement distinctions compared to deaf signers whose difficulty is primarily with handshape distinctions. Whether either of these hierarchies would apply to brain-damaged individuals learning ASL signs is an open area for investigation.

Acquisition order within parameters. Of the four major parameters, the acquisition of handshape cheremes has been examined the most frequently (Doherty, 1985). Boyes-Braem (1973) developed a four stage model for describing the process of acquiring handshapes in ASL. This model was based on the analysis of one one-hour videotape of a deaf child aged two years and seven months. The stages in the model are thought to reflect the child's gradually emerging ability to control weaker fingers. According to Boyes-Braem, anatomical and cognitive constraints at first control the development of baby handshapes. The earliest handshapes produced by infants include those associated with the primary functions of the human hand: pointing and grasping. More complicated and specialized activities such as typing, using chopsticks, and sign language, demand independent manipulation of the weaker middle and ring fingers, which come under conscious control late in development. In sign language, the demand for manipulation of the weaker fingers means that it is physically more difficult to produce more advanced handshape features such as insertion of the thumb between two fingers and crossing adjacent fingers. The HS cheremes hypothesized to be acquired during each of the four stages are as follows: Stage I - A, S, L, baby O, G, 5, C; Stage II - B, F, O; Stage III - I, Y, D, P, 3, V, H, W; Stage IV - 8, 7, X, R, T, (M,N,E). Two additional predictions regarding developmental progression have also been derived from the model: first, that signs formed with handshapes from a stage beyond the child's ability would be produced by substituting those handshapes already mastered; and second, that higher stage handshapes would not be used to substitute for handshapes of an earlier stage (Doherty, 1985).

Boyes-Braem realized that not all of the child's output could be accounted for by this model alone, therefore, she also proposed several secondary factors that could influence a child's performance. One such factor is the child's preference for making contact with the tip of the index finger over other parts of the hand or other fingertips. Another secondary factor is pantomiming. Often handshapes are influenced by an action associated with the referent. When this happens the correct handshape is changed to one that more closely resembles a mimetic representation of the referent. A third possible influence on performance is the nature of the sensory feedback. A sign made within the visual field offers visual feedback that may help to guide production. A fourth factor that may influence handshape is the complexity of the movement required to make a particular sign. There is no systematic empirical data regarding the acquisition of the movement parameter. Movement complexity has been defined by some as the number of movements involved in producing the sign (Coelho, 1982; Grinnell, Detamore, & Lippke, 1976), with a single movement sign considered less complex than a double movement sign. However, this definition has been surrounded by controversy because there is no empirical data to support it. A detailed discussion of movement complexity can be found in a later section of this review.

The fourth and final secondary influence proposed by Boyes-Braem is assimilation, which includes both anticipation and perseveration. Handshapes from adjacent signs are either anticipated or perseverated, which results in "slips of the hands". These types of errors have been extensively investigated by Klima and Bellugi (1979). Most of Boyes-Braem's predictions were supported by her data and additional support has been provided by later studies (McIntire, 1977; Holmes & Holmes, 1980).

McIntire (1977) examined the corpus of ASL signs produced by a deaf child (FF) acquiring the language from deaf parents. The child was videotaped at 13, 15, 18, and 21 months. The study focused on the child's acquisition of ASL handshapes using Boyes-Braem's (1973) model to evaluate the stage by stage progression. The data confirmed Boyes-Braem's model. McIntire (1977) found that virtually all of FF's output in the corpus was from Stage I. Also, handshapes from an earlier stage were regularly substituted for handshapes associated with a later stage. Stage I handshapes were the primary ones used for substitutions (only 4 out of 186 substitutions were not made using

Stage I handshape cheremes). Although Boyes-Braem's model was able to account for most of FF's subsitutions, certain substitution patterns were not consistent with the distinctive features proposed by Boyes-Braem (1973).

Another study with results that support the early emergence of Stage I handshape cheremes was conducted by the hearing parents of a hearing male child (Davey) as he learned both ASL signs and spoken English (Holmes & Holmes, 1980). Davey's communicative behavior was recorded from age 26 weeks through 17 months while both parents communicated with him in signs and spoken words. Of the 8 handshapes Davey was able to produce, five or 63% were from Stage I, two or 25% were from Stage II, and one was unclassifiable according to Boyes-Braem's model (i.e. K).

Although the stage model is strongly supported by the data from these two studies, the model itself has not been systematically investigated. Both studies presented pooled data from various ages rather than age specific data. Hence, the model awaits substantiation from a longitudinal investigation.

Boyes-Braem's model has also obtained support from a study of the developmental acquisition of ASL classifiers (Kantor, 1980). Classifiers are a late developing syntactic component of ASL and reflect certain semantic properties of their noun referents. Their use is linguistically complex, requiring syntactic, semantic, and phonological information for correct choice and function on the part of the user. Kantor's cross-sectional study employed nine congenitally, profoundly deaf children aged three to eleven years. The data revealed that the earliest handshape substitutions used when forming classifiers, show the same relations as those found in the stages of handshape acquisition.

Boyes-Braem's stage model is based on the assumption that as motor control increases more complex handshapes can be produced. However, another system for analyzing handshape motoric difficulty has been developed by Daniloff and Vergara (1984). These investigators have assigned a developmental age to 43 handshape cheremes based on a formula using developmental prehension patterns. "Prehension involves a gradual refinement of motor skill based on both stability of postural muscles and mobility of discrete body parts" (Dennis, Reichle, Williams, Vogelsberg, 1982, p. 21). A comparison of the two systems has revealed that the developmental ages assigned by Daniloff and Vergara (1984) do not follow the stage-wise progression predicted by Boyes-Braem's model. It is clear that future studies are needed to determine which, if either, of the two systems is a valid reflection of handshape motoric complexity.

Only a limited amount of information is available on the order of acquisition, or difficulty, of movement and location cheremes. Acquisition of the various palm orientations has yet to be explored. A proposed sequence for acquisition of movement patterns and palm orientations, based on infant developmental milestones, is presented by the present author in Tables 7 and 9. One study that examined movement in the context of sign acquisition was conducted by Holmes and Holmes (1980). These investigators noted that between 6 and 17 months the movement or sig features prominent in their son Davey's signing included contacting or touch, repetition of movement, side to side action, and movement toward the signer. The sequence of emergence of location cheremes is also available from this study. Davey's most frequent tabs included neutral signing space, elbow/forearm, and head. The frequent occurrence of the head tab is unusual since the number of signs in ASL with head tabs has been determined by Shane and Wilbur (1980) to be relatively small (29%). Shane and Wilbur's (1980) determination was based on a task analysis of a core vocabulary of signs. Doherty (1985) has postulated that Davey's preference for the head tab may have derived from imitation given the prevalence of this feature in the sign models presented by his parents. Since these results are based on a single hearing child additional research is needed to determine whether these results can be generalized to other hearing children and adults acquiring ASL signs.

Motoric requirements. In addition to the four parameters described above signs are differentiated along motoric dimensions such as contact, sometimes referred to as "production mode" (Kohl, 1981), and motoric complexity. Although the suggestion that motoric requirements be considered when selecting signs for training was made a decade ago (Stremel-Campbell, Cantrell, & Halle, 1977) very few studies to date have examined the issue. The studies that have investigated these sign features for their influence on sign acquisition will be reviewed here.

Signs labeled as contact signs are produced with tactual contact occurring between the hands, or between the hand and body, at some point in the sign's execution, whereas noncontact signs are made without any such tactual contact (Kohl, 1981; Lloyd & Doherty, 1983; Doherty, 1985). In Stokoe's (1976) notational system contact has traditionally been described by the motion parameter sig. However, the two sig actions available within Stokoe's system (contactual action, and link/grasp) are not detailed enough to fully describe the type of action that is made when a sign includes contact in its production. In recent years new notational systems have been devised that allow better descriptions of the type and location of touch movements (Friedman, 1976, cited in Doherty, 1985; Mandel, 1981, cited in Doherty, 1985).

Fouts (1972) was the first investigator to suggest that touch may influence ASL sign acquisition. In his training (Experiment 1) of the chimpanzee Washoe it was reported that the performance of nontouch signs was the poorest relative to the other signs being taught under the same conditions. However, a similar experiment (Experiment 2) performed one year later revealed that touch and nontouch signs were acquired with equal ease. Holmes and Holmes also reported a prevalence of touch signs in Davey's sign vocabulary which may suggest a preference for contact in early sign acquisition. Data from severely handicapped children and adults regarding initial sign acquisition also report that touch facilitates sign acquisition. Kohl (1981) trained eight severely handicapped students on eight ASL signs that varied according to several sign features including touch, and found that touch signs were acquired faster than nontouch signs. The generalizability of Kohl's (1981) results are limited due to the small number of stimulus items included, the use of different signs to evaluate the contact/noncontact difference, and the use of only two-handed signs. Also the signs used in training were not evaluated for their production difficulty. Therefore, contact may not have been the only factor that influenced her subjects' acquisition of signs.

In an initial attempt to examine some of the questions raised by Kohl's (1981) study Lloyd and Doherty (1983) conducted an investigation of sign acquisition using a stimulus pool of 40 signs. The influence of contact on the acquisition of each sign was examined by teaching half of the signs with contact and half without contact to two groups of female college students. The results indicated that for one subject group contact signs were acquired more readily than noncontact signs. During recall (same-day and one-week) more contact than noncontact signs were produced correctly by both groups of subjects. Also the decrement in recall from same-day to one-week posttraining was smaller for contact than for noncontact signs. In a later study Doherty and Lloyd (1983) trained 16 mentally retarded adults to produce 16 ASL signs. The signs varied in the number of hands required for their production (either one or two hands), and in their degree of iconicity (moderate and high translucency signs were used; See later section for discussion of translucency). Contact was found to facilitate sign learning in all but the moderately translucent two-handed sign condition. For these two-handed signs contact and noncontact signs were learned with equivalent ease. Examination of the data led the authors to propose that some of the two handed signs of moderate translucency used in the study may have been easier to learn without contact because of the type of contact required for their production. It was noted that signs which required contact midway through their execution e.g., EGG, FORK, were more likely to be incorrectly produced because of failure to follow the continuous motion through to its completion. Rather, the subjects tended to end production of these signs at the midway point of contact. Therefore, for these signs, the noncontact mode facilitated acquisition.

In the studies discussed above contact was consistently found to facilitate sign acquisition. Contact is also apparently a feature that is preferred by subjects during the early stages of sign learning. In Lloyd and Doherty's (1983) study college students were found to add contact to signs initially taught without contact more often than they deleted it from signs initially taught with contact. This finding is quite different from what is seen among experienced signers. Fluent signers are more likely to delete contact from signs during conversation as a means of emphasis or stress (Wilbur, 1979). Therefore contact has been implicated as a sign feature that may be particularly important to novice signers early in their sign training.

Explanations that have been offered for the facilitative effect of contact on sign learning have stressed the importance of tactile feedback (Kohl, 1981). Support for this idea comes from research in the area of learning and memory which indicates that the amount of sensory and perceptual processing an item receives directly affects the item's strength of storage and retrieval (Craik, 1973; Norman & Rumelhart, 1970). Two related theories of motor skill learning (Adams, 1971; Schmidt, 1975), first discussed by Lloyd and Doherty (1983), have proved to be helpful in explaining how additional sensory feedback, such as touch, can act to enhance acquisition and recall of signs. Although different terms are used by each investigator, the concepts referred to by the two theories are similar. Movements are believed to be initiated by a concept referred to as the "memory trace" (recall memory). When a movement is reproduced the feedback received from the senses (vision, kinesthesis, touch, and pressure) is believed to combine to produce a "perceptual trace" (recognition memory). The "perceptual trace" then functions to guide the limbs to their correct final location, and to judge whether the movement has been produced without error. If the movement is judged to be inaccurate the "perceptual trace" allows the actor to recognize the specific error associated with the movement and make the necessary adjustments. The strength of the "perceptual trace" is believed to increase as a function of the quality and amount of sensory feedback received. The stronger the perceptual trace, the more accurate the motor memory (Adams, 1971; Adams, Marshall, & Goetz, 1972; Schmidt, 1975). Therefore, when individuals are trained to produce signs the "perceptual trace" is strengthened when touch is added as a feature, resulting in the increased likelihood that the sign will be recalled at some later time.

In addition to the increased amount of sensory information provided by signs that include contact in their production, contact also provides specific information regarding where the sign is produced. Using this information Doherty (1985) has proposed an explanation for why locational information plays a key role in the memory of signs by deaf signers (Klima & Bellugi, 1979). It is suggested that contact may facilitate sign acquisition by allowing the learner to register in a concrete fashion the location of signs at some point in their execution. Furthermore, if the location parameter is indeed acquired first, and contact assists in location specification, then contact might be most likely to facilitate acquisition during the initial stages of learning. There are presently a variety of language impaired individuals being trained to communicate via ASL signs. Further research is needed to examine whether contact also facilitates sign acquisition in these severely impaired populations.

The motoric dimension of reduplication has not been extensively investigated. A few studies have advocated the selection of single movement signs rather than repeated movement signs on the assumption that the former are less complex than the later (Grinnell, Detamore, & Lippke, 1976; Shane & Wilbur, 1980). No empirical data are available to support the assumption.

In their observation of a hearing child acquiring signs, Holmes and Holmes (1980) noted that the child spontaneously added reduplication to signs originally taught as single movement signs. Doherty (1985) has suggested that the addition of repetition during initial stages of sign acquisition may provide additional sensory information that could serve to facilitate sign learning. It is evident that more studies need to be conducted to clarify the role of repetition in sign learning and retention.

Motoric or production complexity, another sign feature that in the past has not received careful analysis, will be the final feature to be addressed in this discussion. Sign motoric complexity has commonly been determined by the number of distinct movements that compose the sign (Kohl, 1981; Coelho, 1982). Hence, signs requiring the production of two distinct motor movements would be considered more complex, therefore more difficult to acquire, than signs that require only one movement, and signs requiring no movement (static signs) would be considered least motorically complex. One study (Coelho, 1982) that examined the influence of motoric complexity, as defined above, on the acquisition of Amer-Ind signs found that signs of low and medium motoric complexity were more easily acquired than those of high motoric complexity. Therefore defining ASL sign motoric complexity according to the number of discreet movements involved in producing the sign was supported by Coelho's (1982) results.

Despite Coelho's (1982) positive findings ASL sign motoric complexity needs to be more empirically defined. One approach might be to hierarchically arrange the cheremes associated with each of the four sign parameters using motor skill development data. This information can then be combined to render a specific production complexity value for each sign. By redefining motoric complexity in a more empirical manner differences in production difficulty can be more easily assessed and compared. The ability to isolate the value of each sign's parameters individually will allow more specific information to be obtained regarding the motoric features that influence sign acquisition.

<u>Conceptual features</u>. The final category of sign characteristics to be discussed emphasizes the semantic

information conveyed by sign referents in association with sign formation. Although there is a sizeable body of literature on the influence of iconicity on sign acquisition it is only recently that studies have been conducted to examine the influence of translucency on sign acquisition. In the following discussion definitions for the features of iconicity and translucency will be presented along with reasons for the switch in experimental emphasis away from sign iconicity to the current focus on sign translucency. Additionally, studies that have examined the influence of translucency on sign acquisition will be reviewed.

An important attribute of manual sign has been that of visual representativeness. According to Luftig, Page, and Lloyd (1983) this visual attribute of sign facilitates learning by allowing the relationship between a sign and its referent to be handled on a more concrete basis. According to Karlin and Lloyd (cited in Luftig et al., 1983) visual representativeness can be delineated along a continuum of transparency, with one end identified as manual sign iconicity (the sign and referent physically resemble each other) and the other as manual sign opaqueness (little or no relationship perceived between sign and referent). Translucency, considered to fall between the two extremes of iconicity and opaqueness, is defined as the degree of perceived relatedness between a sign and its meaning (Luftig et al., 1983).

Although a substantial amount of research has been conducted on the facilitative effects of iconicity on sign language learning (Bonvillian & Nelson, 1976; Luftig & Lloyd, 1981; Coelho, 1982), recent research has indicated that sign language is less iconic than originally believed (Klima & Bellugi, 1979). Therefore, the focus on iconicity may have been misguided. It has been suggested that rather than iconicity, translucency may be the key factor in facilitating acquisition of signs (Luftig & Lloyd, 1981). Luftig et al. (1983) have argued that because the sign learner is usually shown the sign with simultaneous presentation of its referent, the attribute of translucency more nearly approximates real-life learning of signs. There is experimental evidence to indicate that translucency facilitates sign learning in normal hearing adults (Luftig & Lloyd, 1981), and autistic children (Konstantareas, Oxman &

Webster, 1978). In their study Luftig and Lloyd (1981) investigated how a combination of high and low levels of sign concreteness and translucency would influence sign learning. They found that significantly more high translucency-high concreteness signs were acquired than low concreteness-low translucency signs, with mixed list conditions not significantly different from each other in terms of learning performance. Based on their findings Luftig and Lloyd (1981) concluded that "... sign translucency may be a better predictor of sign learnability than iconicity for severely language-impaired populations..." (p. 57).

Clinicians involved in signing programs with severely language impaired individuals are particularly interested in the influence of sign characteristics on sign acquisition. Their interest stems from a desire to choose the best signs for inclusion in an initial sign lexicon. For clinicians working with nonfluent aphasics there are limitations in the development of such a lexicon. These limitations are due to the motor impairment (apraxia) that often accompanies the aphasic language impairment. Considering all of these factors and the literature reviewed above, the sign characteristics that should facilitate acquisition among aphasics include: moderate to high translucency, contact, and low production difficulty/complexity. Studies are now needed to examine these predictions in aphasic subjects, in order to determine their validity and hence importance in sign acquisition.

Manual Communication Training Programs With Aphasic Patients

In most human societies, except among the deaf, spoken language serves as the primary means for communication. However, tools such as facial expression, eye movements and bodily gestures can also be used to convey information and express feelings and attitudes. Within the last fifteen years there has been a growing interest in training aphasic individuals to use these alternative communication methods. The main reason that some clinicians favor training aphasics in manual techniques is to provide an alternate means of communication (temporary or long term) or to augment residual verbal skills. Some clinicians use nonverbal methods as a facilitator for verbal language production because they want to make their aphasic patients realize that they can communicate better than they can speak. Despite the growing interest in manual training only a few studies have been published which examined the viability of manual techniques as a communication alternative for aphasic patients. The studies conducted have generally reported positive results. However, due to poor description of subjects it has been difficult to establish firm conclusions and many questions still remain unanswered. A few of the unanswered questions are: (a) How much success can aphasics expect in acquiring communicative gestures? (b) What is the influence of motor impairment (apraxia) on manual communication learning? (b) What is the actual communicative use of the limited number of signs acquired? and (c) Which cerebral hemisphere is responsible for processing manual gestures?

Discussion of Training Programs

One of the first attempts to train aphasic patients to use manual signs for communication was undertaken by Eagleson, Vaughn, and Knudson (1970). These signs were developed as an interim communication system to allow nonfluent aphasics to express urgent self-care concepts such as "I am hungry,". In constructing this manual system signs were freely borrowed from the American Indian sign code and the sign language used by the deaf. The twelve signs that were ultimately selected were first presented to a 56 year old expressive aphasic for training. Despite problems in comprehension and motor coordination the subject was able to learn all of the signs in a few hours and return to his family after a six year absence. Following this patient's success 30 additional expressive aphasic patients were successfully trained to produce the signs. Another positive result of the training was the patients' observed increased drive to succeed in verbal communication.

The manual alphabet has also been used with nonfluent aphasic individuals in manual communication training. Chen (1968) initially devised a left-hand manual alphabet which closely simulated the printed form of each letter. In order to reduce the difficulty of having to spell out each word Chen (1968) also developed a gestural system or manual shorthand based on this alphabet. Eighteen aphasic stroke patients were instructed in this "talking hand" communication system with generally positive results. Due to the lack of details regarding the subjects' specific aphasia diagnosis it is difficult if not impossible to understand the results obtained. Chen (1968) noted that sensory aphasics were unable to learn the system, however, it is not clear if the 5 patients who obtained poor results were the ones diagnosed as sensory aphasics. Another criticism that has been advanced pertains to Chen's (1968) assumption that his manual alphabet plus gesture system is easier to learn than the standard manual alphabet used by the deaf. Christopoulou and Bonvillian (1985) propose that because Chen's system employs letters and gestures it may in fact be more difficult to acquire than a sign system where each sign represents one concept. Also, since spelling is often impaired among aphasics, acquisition of such a system could prove very difficult. Due to the questions left unanswered in this study, its implications for the training of aphasic populations remain unclear.

Stuart-Smith and Wilks (1979) also developed a unique gestural system to provide an alternative means for severe aphasics to communicate. Their system is based on the automatic gestures seen in day-to-day conversation. In this program aphasics are trained to reincorporate these basic gestures into their mode of communication as a supplement to their limited verbal skills. Four subjects were trained to produce the 45 functional gestures. Success was achieved with only two of the four subjects. Subject personality variables and family dynamics were presented as reasons for the poor results with the remaining two subjects. These subjects also exhibited body apraxia, although it should be noted that one of the subjects who achieved success on the gestural program was also diagnosed as apraxic. Hence, a diagnosis of apraxia does not necessarily indicate an inability to produce communicative gestures. It is because of results like those of Stuart-Smith and Wilks (1979) that it is difficult to know which subjects will indeed be successful in a gesture training program.

More recently investigators have begun using formal gestural systems, ASL vocabulary signs, and

Signed English in communication training programs for aphasic patients. The sign systems used have either been Amer-Ind Gestural Code or one of the sign languages used by deaf persons. One reason frequently given for the use of Amer-Ind in some of these investigations is its ease of recognition (80 to 90 % iconic), imitation (Daniloff, Fritelli, Buckingham, Hoffman, and Daniloff, 1986) and production (Daniloff and Vergara, 1984). ASL signs, on the other hand, have been determined to be only between 10 and 30 percent iconic, though, there are indications that ASL signs are significantly more translucent (R. L. Luftig, personal communication, March 8, 1983).

Since aphasic patients often exhibit an associated hemiplegia, signs that will be used in aphasic training programs need to be adapted for one-handed productions. Coelho (1982) has examined this issue and reported that when such an adaptation was made for the 37 Amer-Ind signs used in his study, and presented to 20 normal subjects, correct identification of the signs was only 34%. Based on this finding he concluded that ..."a great deal of the Amer-Ind system signs' iconicity is lost when they must be adapted into one-handed signs" (p. 145). He subsequently suggested that when two-handed Amer-Ind signs are produced with one hand the Amer-Ind signs "...may be no more recognizable than signs from other sign systems (for example, American Sign Language)" (Coelho, 1982, p. 145). Because his aphasic subjects acquired one-handed Amer-Ind signs as well as fabricated signs, Coelho further suggested that it may be more important to use a psycholinguistic definition of iconicity which considers associational cues e.g., translucency, when selecting signs for a training program.

Coelho believes that his results should provide an incentive for clinicians to investigate training programs that utilize sign systems other than the Amer-Ind system. Some additional reasons for employing one of the sign languages of the deaf, rather than Amer-Ind, in aphasic training programs include a more extensive vocabulary and the potential to communicate with a much larger established population of signers. Unfortunately no studies have been done to investigate the long term advantages of training aphasics on one versus another formal sign system.

Holmes (1975) used the Paget-Gorman sign system with a 60-year-old right-handed male who suffered a left middle cerebral artery infarct and mild diabetic neuropathy. The patient was diagnosed as a Wernicke's aphasic with only fair comprehension. His performance on the BDAE revealed that visuospatial organization, praxis, and motor sequencing were adequately retained. Further examination however suggested some apraxia. Holmes reported that the patient was able to acquire 120 signs (the majority of which were nouns) with very little difficulty. The patient was also able to name in sign objects which he could not name verbally. Holmes reported very little success with conveying the concept of syntax to the patient hence, he was unable to combine the signs acquired to generate short phrases and tended instead to use the signs primarily for labelling.

Bonvillian and Friedman (1978) reported similar results with a 49 year-old male aphasic and dysarthric patient who also exhibited severe apraxia. The patient's brain injury was the result of head trauma. Over the nine months of training the patient mastered 79 ASL signs, but, as in Holmes' study, he did not spontaneously combine the signs acquired to produce short phrases. The authors neglected, however, to state the patient's hand preference or the general site of lesion, which makes it difficult to adequately interpret the results.

Coelho (1982; 1987) attempted to train 12 chronic nonfluent aphasic patients to produce Amer-Ind sign combinations following training on 37 individual signs. The training of signs progressed through three successive levels: imitation, recognition, and production. Following completion of the production training a generalization task was presented for all signs successfully acquired. Although the results of individual sign training with the 12 aphasic subjects were varied and limited a significant relationship was found between severity of aphasia and success in the acquisition and generalization of manual signs. Because only seven of the 12 subjects acquired an adequate number of individual signs, few combinations were able to be trained. According to Coelho (1982) the moderate to poor results imply that there may be threshold of severity of aphasia below which acquisition is negligible. Furthermore, "...just because an individual aphasic can 'acquire' signs does not mean he can 'use' them" (p. 138). It is felt that Coelho's (1982) statement is too broad since it was not made clear whether the patients were in an environment where use of signs for communication on a daily basis was encouraged. Despite Coelho's poor results authors of a recent case study (Code & Gaunt, 1986) have reported that an aphasic patient taught only a few Makaton signs (N=10) was observed to use the signs spontaneously in everyday communication. Furthermore, based on additional observations the authors felt that the subject would continue to make progress toward generalizing the signs learned.

Two additional case studies of the acquisition of Amer-Ind and ASL (Heilman, Rothi, Campanella & Wolfson, 1979; Kirshner & Webb, 1981) have indicated that some aphasic subjects demonstrate the ability to combine signs and generalize their use beyond the structured training situation. In both of these studies the subjects acquired over 100 signs and were able to sequence them to produce short phrases. This apparent sequencing ability suggests that some syntactic skills may be retained in some aphasics. Both of these subjects retained moderate to good reading comprehension following their stroke, which may be directly related to their observed sequencing ability.

The largest literature on the acquisition and use of signs by aphasic patients was compiled by Skelly (1979). In her book Skelly (1979) described the results of ten Amer-Ind training projects, some of which were conducted by the author, for approximately 180 subjects. The results of these projects were fairly positive, however, there was such a wide range in treatment methods employed, subjects used, project durations, and trainers, that generalization across projects is difficult. One major difficulty was the confounding of verbal apraxia (the inability to produce the movements associated with speech) and aphasia in some of the patients. Despite all the limitations, Skelly's report indicated that most of the patients were capable of acquiring signs that could be used to express basic needs and wishes.

In addition to its use for the expression of basic needs, gestural communicative techniques have been used to facilitate the rehabilitation of spoken language. This has generally been accomplished by pairing gestures with spoken language using a deblocking paradigm. Deblocking is a therapy strategy based on the concept of transcoding developed by Weigl (1974). In a deblocking paradigm a disturbed function (in this case spoken language) is paired with a more intact function (in this case gesture) (Rao & Horner, 1978). The first study that employed this technique effectively was conducted by Skelly, Schinsky, Smith, and Fust (1974). Six oral and verbal apraxic patients were trained to produce Amer-Ind signs accompanied by speech. At the end of two months all six patients had mastered 50 signs. At the end of six months they had all developed some spontaneous oral verbal production synchronous with their signing. By the conclusion of the project five patients had made considerable progress in using speech accompanying signs, and four patients were able to combine several words to produce short phrases. In another study Amer-Ind was used by Rao and Horner (1978) to deblock listening, reading, and speech. The patient, a 38-year-old male, was described as profoundly aphasic, both receptively and expressively, and mildly apraxic, with a striking residual gestural ability. He had retained the ability to recognize and spontaneously produce gestures. Following 18 months of training, although gesture was the most fluent and productive mode of communication, the patient's conventional linguistic skills were also showing remarkable improvement. A more recent study (Code and Gaunt, 1986) that employed a deblocking type paradigm, with a severely apraxic-aphasic patient, also reported improvement in access to single words following treatment. The patient was trained over an eight month period to produce 10 hand signs from the Makaton Vocabulary. At the end of the training period the patient indicated an improved ability to produce the single word equivalent when cued with the appropriate hand sign, and alternatively to access the associated sign when cued with the appropiate word. The encouraging results of these studies indicate that the pairing of spoken langauge and gesture in training work, in some aphasic patients, to facilitate access to the impaired language ability. Therefore, gesture does not necessarily have to remain the only mode of communication for those who have been trained successfully in its production.

Discussion of Training Outcomes

The studies discussed above indicate that for nonfluent aphasics who have experienced little or no success with vocal language retraining, training in the use of certain aspects of a gestural language proved more viable. In many instances it was reported that when patients were able to express their basic needs and wants with gestures their social behavior improved. Most of these studies, however, lacked careful descriptions of the patients motor impairments and none discussed the type of errors produced by the patients during various aspects of training. The patients' desire to communicate, and the influence of some of the various sign features on acquisition, are additional areas that were not explored. Due to the many issues not addressed in the previous studies, and the obvious practical benefits of gestural language training for aphasics, additional research is needed that will address some of the unresolved problems.

The limited success experienced by many aphasic patients in the acquisition of manual communication skills has also been difficult to explain, particularly since the results of the training programs do not provide definitive support for either of the four theoretical positions i.e., asymbolia, modality, cognitive, and apraxia. For example, the asymbolia hypothesis is both supported and rejected by the research since aphasics' motor skills have been shown to be impaired, although less impaired, than their auditory-vocal skills. The data are also equivocal with regard to the apraxia and modality theories. In the study conducted by Stuart-Smith and Wilks (1979) apraxia was associated with difficulty in acquiring gestures, yet Code and Gaunt (1986) presented information on a patient with severe limb apraxia who was successful in manual language acquisition. Additionally, inadequate reading comprehension scores have been found in patients who were successful in using gestures to communicate (Code & Gaunt, 1986; Eagleson & Knudson, 1970; Holmes, 1975). It is obvious from the studies that have obtained results at variance with the theoretical models that these models have not been successful in being able to explain why some aphasics can acquire and use gestures to facilitate communication while others cannot.

In addition to the proposed theories other investigators have attempted to understand why gestures have worked for some aphasics by looking at the specific differences between speech and gesture. Since sign language and fingerspelling are visuomotor rather than auditory-vocal communication systems, it has been suggested that the pattern of cerebral organization may differ between the two systems of speech and gesture. As discussed earlier, Poizner et al., (1979) have obtained results indicating that comprehension of ASL may in fact be more bilaterally represented than English. Thus, it may be the more bilateral cerebral representation of manual signs that contributes to its successful acquisition by aphasics. The importance of the right hemisphere in the acquisition of gestures is further highlighted by the observation made by Heilman et al., (1979) of an aphasic patient who had successfully acquired Amer-Ind gestures and later lost his ability both to comprehend and use the gestures subsequent to a right hemisphere stroke.

Another explanation that has been proposed for the success of gestural programs with aphasics has been that there is an increased opportunity for the clinician to provide proprioceptive information regarding the gesture by molding and guiding the subject's hands during training; and it is not possible to provide this type of manipulation to the speech musculature.

There are probably many additional reasons that we have not yet explored for why gestural communication therapy programs are frequently more successful than speech-based approaches with aphasic subjects. It is hoped that future studies will continue to examine how gesture can be used by aphasics for communicative purposes, and in so doing provide further information on why gesture has developed as such a viable communication alternative.

CHAPTER III

Method

Subjects

Subjects were 8 aphasic adults (males = 5, females = 3) and 6 non-neurological adults served as controls (males = 3, females = 3). Seven of the eight aphasics and all of the controls were native English speakers. All subjects were right-handed as determined by the Annett Handedness Inventory (Annett, 1970). The two groups were not significantly different at the .05 level for either age or education (see Table 1). The time since stroke was quite variable among the groups with months poststroke ranging from 4 to 190.

The subjects were divided into four groups for training purposes. Four aphasics were assigned to group A and four to group B. The six control subjects were also divided into two groups of three subjects each and assigned to groups C and D. The aphasic subjects were selected on the basis of the following criteria:

1. Diagnosed as aphasic on the basis of scores obtained on the Boston Diagnostic Aphasia Examination

Table 1

Subject Biographical Data

Subj	Age	Sex	Educ	Occupation	Months Post Onset	Aphasia Type	Lesion Location	Speech Therapy	Hemipares	No. Days Between Prb1 and Prb2
Aphasics										
JS	68	M	13	Corrections Aide	50	mild express	L fronto-pariet	Y	R	7
AA	59	M	15	Electroplater	4	mild express	L fronto-pariet	Y	recov R	7
DJ	62	F	16	Admin Assistant	104	mild express	L frontal	Y	R	7
RB	62	M	11	Bldg Engineer	60	mild express	L fronto-pariet	Y	recov R	7
MF	47	M	17	Law Student	21	mix nonfluent	L fronto-pariet	Y	R	7
SS	52	F	16	Cosmetologist	50	Broca	L fronto-pariet	Y	R	1
PB	56	F	12	Clerk/housewife	190	mild express	L fronto-tempor	Y	R	7
EA	56	M	18	Engineer Admin	51	mix nonfluent	L fronto-pariet temporal	Y	mild R	7
Mean	57.75		14.75		66.25					
Controls										
BB	58	M	16	Translator						7
JB	58	F	18	Elem Teacher						7
BL	43	F	17	SP ED Teacher						7
JT	49	M	16	Military Police						8
FM	66	M	18	Musician/Teacher						7
EW	62	F	13	Clerk						1
Mean	56		16.33							

(BDAE) (Goodglass & Kaplan, 1972, 1983).

2. Alert and well motivated.

3. Tested no sooner than three months poststroke.

Prior to the experimental sessions the aphasic subjects were:

1. Evaluated to determine their level of praxic functioning.

2. Evaluated to confirm that they had no prior knowledge of the 24 signs to be presented during training.

3. Trained to respond to all task relevant instructions using example sign stimuli similar to those used in the study.

4. Evaluated to confirm that they were not experiencing any tactile impairment on the left side of the body or any other body areas associated with the signs to be trained. Tactile perception was examined using a tactile perception test created by the present examiner (see Appendix A) and administered according to the method developed by Fink, Green and Bender (1952) to administer the face-hand test (Fink et al., 1952).

Prior to the experimental sessions the control subjects were:

1. Evaluated to confirm that they had no prior

knowledge of the 24 signs to be presented during training.

2. Trained to respond to all task relevant instructions using example sign stimuli similar to those used in the study.

Experimental Design

A 3 x 2 x 2 (Translucency x Body Contact x Production Complexity) analysis of variance design was used in this investigation. The three independent variables were translucency, production complexity, and body contact. Levels of the independent variables were high vs. medium vs. low (translucency), contact vs. no contact (body contact), and high vs. low (production complexity). The dependent variables were total number of training trials (handshaping and physical guidance trials) administered during acquisition, and total number of correct parameters produced on the immediate posttraining test, the same day posttraining probe (probe 1) and the one week posttraining probe (probe 2). Subjects were randomly assigned to groups for order of sign presentation. A non-neurological control group was used.

Materials

Pretraining Tests

The following assessment was made of each aphasic subject prior to beginning sign training:

1. Type and Severity of Aphasia. The Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1972) was used in this study to determine the type and severity of aphasia each subject exhibited. The BDAE test battery was devised to provide a comprehensive assessment of the components of language that may be disturbed following brain injury (Goodglass & Kaplan, 1972). Twelve function areas defined by factor analysis as related to communication, are systematically examined by this test. Five main language areas are examined, they include: Conversational and expository speech, auditory comprehension, oral expression, understanding written language and writing. A total of 34 subtests comprise the battery. Scoring of each subtest begins with determining the number of correct items. Raw scores are then converted to z-scores derived from a normative study of aphasic patients. By completing the seven 7-point scales included in the "Rating Scale Profile of Speech Characteristics" the patient's type and severity

of aphasia can be determined.

An evaluation of the reliability of the subtests was obtained by examining the protocols of 34 aphasic patients distributed through five levels of severity (Goodglass & Kaplan, 1972). Using the Kuder-Richardson method of determining subtest reliability, coefficients have been obtained that indicate good internal consistency within subtests. All the internal reliability coefficients, except one, are above .80.

Norms were collected from a non-brain-injured population of 147 subjects sampled across age and educational levels (Borod, Goodglass & Kaplan, 1980). All the subjects were English speaking and right-handed. Means, standard deviations and ranges were computed for each group. Based on the performance of the subjects it was suggested that the lowest score for each group be the cut-off below which impairment may be expected.

2. <u>Auditory Comprehension</u>. The "Short Version" of the Token Test (DeRenzi & Faglioni, 1978) was administered to assess auditory comprehension. The test consists of 20 plastic tokens. Ten are circles and ten squares. Five squares and circles are large and five squares and circles are small. In each series

of 5 circles or squares, the colors black, white, red, yellow and green are represented. The test is administered by presenting the 20 tokens, arranged in a specified manner, to the seated subject. The test contains 36-items presented in six parts. This test differs from the original Token Test (De Renzi & Vignolo, 1962) due to the inclusion of a sixth section, Part I. Part I was added to lower the test's range of difficulty. The patient earns one credit for each successful performance on the first try. If the patient fails or does not respond for five seconds a second chance is provided. Success on the second try is given half credit.

Normative data was obtained for 215 non-brain-damaged control subjects and 200 aphasic patients. The authors recommend that the scores be adjusted for education. The adjusted score that was found to best distinguish normal from pathological performance was 29. Only 5% of the control subjects scored lower and 7% of the aphasic patients scored higher. A scheme for grading auditory comprehension based on the adjusted scores is presented for making clinical discriminations. The authors found that scores below 17 distinguished patients with global aphasia from the higher scoring ones with Broca's aphasia.

3. *Evaluation of Gesture Production (Praxic Functioning)*. The battery of tests administered to evaluate praxic functioning is presented in Appendix B.

Two normed tests of apraxia were administered to examine praxic functioning, they were: The Kimura Hand Posture Copying Test (Kimura, 1982) and Kimura's Movement Copying Test (Kimura, 1982).

The Kimura Hand Posture Copying Test is a slightly abbreviated version of the Kimura Hand Posture Copying Test described and normed in Kimura (1982). This test requires the subject to copy five hand postures, most of which are taken from the deaf alphabet. Since the hand on the same side as the lesion is typically unaffected by the stroke this hand is used for the test. Each posture is scored 2, 1 or 0 depending on whether it is correctly copied on the first or second trial, or not at all. The maximum score is 10.

Kimura (1982) reported data from 118 brain-damaged patients with unilateral brain damage, 72 left hemisphere damaged patients and 46 right hemisphere damaged patients. The scores reported by Kimura were for the hand on the same side as the lesion. The mean score of the patients with left hemisphere damage was 65.5% correct, compared to the mean score of the patients with right hemisphere damage which was 79% correct. Kimura suggested that scores below a 90% performance level of the mean score of the right hemisphere damaged patients, be considered impaired. Based on Kimura's recommendation the cut-off value for impairment was 71.1% correct.

Normative data were obtained from a group of elderly normals (Kimura, 1982). The group performed at a level similar to that of the right hemisphere group (normals, 72% correct; right hemisphere lesions, 79% correct).

Testing of additional static hand postures was also included in the examination of praxis to enable a thorough evaluation of the subjects' ability to make all hand postures to be used in training.

The Kimura Movement Copying Test is an abbreviated form of the movement copying task described in Kimura and Archibald (1974). The form used in the present battery is described and normed in Kimura (1982). This test requires the subject to imitate movements of the hands and arms that form unfamiliar meaningless sequences. Three series of movements involving one hand and arm are presented for imitation. The patient copies the movement as soon as the experimenter has completed it. Several features of a particular movement sequence are independently scored, such as hand posture, hand orientation, occurrence of movement, direction of movement, etc. If on the first trial the movement pattern is not correct in all these characteristics a second trial is given. Each component of the sequence is scored 2, 1 or 0 depending on whether it is correctly performed on the first or second trial, or not at all. The maximum possible score is 24.

Kimura (1982) reported data from 118 brain-damaged patients with unilateral brain damage, 72 left hemisphere damaged patients and 46 right hemisphere damaged. The scores reported by Kimura were for the hand on the same side as the lesion. The mean score of the patients with left hemisphere damage was 59% correct, and those for the right hemisphere damaged was 78% correct, which was significantly higher. Kimura suggested that scores falling below a 90% performance level of the mean score of the right hemisphere damaged patients, be considered impaired. Based on Kimura's recommendation the cut-off value for impairment was

70.2% correct.

Normative data were obtained from a group of elderly normals (Kimura, 1982). The group of normals performed at a level close to that of the right hemisphere group (normals, 85% correct; right hemisphere group, 78%).

The two apraxia tests discussed above were used to evaluate nonrepresentational movements. Representational movements were investigated through a combination of selected BDAE Ideomotor Apraxia test items and items selected from Brown (1972). The items chosen from those two sources evaluated buccofacial movements, arm and hand movements that are both transitive and intransitive, and whole-body movements. Within each of the limb movement types, movements made on the body and away from the body were also evaluated.

4. Evaluation of Gesture Comprehension. The ability to recognize meaningful, nonlinguistic pantomimed action was evaluated by The Pantomime Recognition Test (Benton, Hamsher, Varney, Spreen, 1983). Each pantomime on the test shows a man pretending to use a common object such as a spoon, pen,

or saw, followed by 7 seconds of blank tape. The subject is required to point to drawings of objects whose pantomimed uses are shown in a series of videotaped performances. Each page of the test booklet contains four drawings for each test item. The four response choices include the correct choice (e.g. saw), a semantic foil (an object belonging to the same class as stimulus, e.g., axe), a neutral foil (an object whose use is pantomimed elsewhere on the test, e.g., pen), and an odd foil (an object whose use is not suitable for pantomime, e.g., train). There are 30 test items, and four practice items. Each test item is scored one point for each correct choice.

Normative data have been obtained from 30 non-brain-damaged hospitalized patients (Benton et al., 1983). The non-brain-damaged subjects' scores ranged from 26-30. On the basis of these results, scores of less than 26 were classified as defective.

Data has also been obtained from 105 patients with left hemisphere brain damage. About 30% of the group made perfect or near-perfect scores (29-30) and about 60% performed within the normal range. The remaining patients obtained either mildly defective (24-25) or severely defective (10-19) scores.

Other subtests included in the apraxia battery were the test of visual discrimination, portrayal of emotions, kinesthetic memory, kinesthetic-visual matching, and movement identification. These tests were developed by the present author for the purposes of this experiment. The visual discrimination subtest evaluated the ability to discriminate between two handshapes. The ability to portray emotions with the face was tested on the portrayal of emotions subtest. For the kinesthetic memory task the subject was required to close his/her eyes and the hands were molded into a handshape, after which the subject was required to reproduce the handshape first with one hand then the other. Subjects were required to perform the task with their left hand. The kinesthetic-visual matching task required the subject to choose from an array of three pictures the picture that corresponded to the handshape his/her hand had been molded into. The movement identification task required the subject to choose the three pictures that corresponded to the movements performed by the experimenter.

5. Subject's Desire to Communicate. The subject's desire to communicate was the final area assessed.

Several of the questions in this assessment were based on Sutherland and Kates (1975) suggestions for assessing communication needs in language impaired subjects. The remaining questions were developed by the present author (see Appendix C).

Signs

The English glosses for the 24 signs employed in training are displayed in Table 2. Of the 24 signs used in this study 15 were normally produced using one hand and 9 of the signs required two hands for their correct production. For the purposes of this experiment all signs were taught using one hand. Therefore, the 9 bimanual signs were modified into unimanual signs. The 24 signs were chosen from Fristoe and Lloyd's (1980) suggested core lexicon of signs and from the items suggested by Skelly (1979) as important for a beginning sign vocabulary. Additional signs were obtained from Fristoe and Lloyd's (1979) compilation of 850 words which appeared in several sign manuals. Two signs CHILD and PIPE were not obtained from either of the above mentioned sources. They were included in order to obtain the desired number of signs in each category. The two reference sources for sign production were A Basic Course in American Sign

Table 2

English Glosses of Sign Stimuli Organized According to Translucency, Body Contact, and Production Complexity

Sign	*M* Translucency	Body Contact	Motoric Complexity
	LOW TRANSLUCENCY (≤3.00)		
APPLE	2.09[a]	+BC	HIGH
EGG	1.40[c]	-BC	LOW
PIPE	2.17[a]	+BC	HIGH
SHOES	1.70[c]	-BC	LOW
STORE	1.67[c]	-BC	HIGH
TOILET	1.63[b]	-BC	HIGH
WATER	2.71[a]	+BC	LOW
WOMAN	2.66[b]	+BC	LOW
	MEDIUM TRANSLUCENCY (≥3.01 ≤5.49)		
BLANKET	3.53[a]	-BC	LOW
BOOK	3.83[c]	-BC	HIGH
CAT	4.29[a]	-BC	LOW
CLOTHES	3.33[c]	+BC	HIGH
COFFEE	3.30[c]	-BC	HIGH
COP	4.74[a]	+BC	LOW
FOOD	3.97[a]	+BC	LOW
MAN	3.03[b]	+BC	HIGH

continued

(Table 2 continued)

English Glosses of Sign Stimuli Organized According to Translucency, Body Contact, and Production Complexity

Sign	*M* Translucency	Body Contact	Motoric Complexity
	HIGH TRANSLUCENCY (≥5.50)		
AIRPLANE	5.71[b]	-BC	HIGH
BABY[d]	6.10[c]	+BC	HIGH
BED	6.23[b]	+BC	LOW
CHILD	6.03[a]	-BC	LOW
COMB[d]	6.54[c]	+BC	HIGH
DRINK	6.77[a]	-BC	LOW
PENCIL	5.87[c]	-BC	HIGH
TELEPHONE	6.86[b]	+BC	LOW

Note. -BC = no body contact; +BC = body contact.
[a]Mean translucency values taken from "Ratings of Sign Translucency and Gloss Concreteness" by R. L. Luftig, L. L. Lloyd, and J. L. Page, 1982, Sign Language Studies, 37, 305-343. Adapted by permission.
[b]Mean translucency values taken from "Ratings of Perceived Translucency in Manual Signs as a Predictor of Sign Learnability" by R. L. Luftig, J. L. Page, and L. L. Lloyd, 1983, Journal of Children with Communication Disorders, 6, 117-134. Adapted by permission.
[c]Mean translucency values taken from Appendix E.
[d]The signs BABY and COMB were taught as body contact (+BC) signs.

Language (Humphries, Padden & O'Rourke, 1980) and *A Dictionary of American Sign Language* (Stokoe, Casterline & Croneberg, 1976).

The signs were divided according to their rated translucency into groups of high, medium, and low translucency (see Table 2). Signs were also classified into two groups according to whether they involved body contact (touch) in their production and into two additional groups according to their production complexity value (see Table 2). Eight signs were chosen for each translucency level. Twelve signs were also chosen for each level of the other independent variables (12 touch and 12 no touch signs; 12 high and 12 low production complexity signs).

Randomization of Signs. The signs were randomly assigned to one of eight sets to yield a single random order of presentation for training all subjects. Given in Table 3 are the English glosses for the 24 stimulus items in the order of their presentation. The eight sign sets were further divided into two subsets labeled A through D and E through H for administration during training. The two subsets did not differ significantly in their average translucency, $t(22) = 1.58$, $p = .13$, production complexity, $U = 62.5$, $p = .59$, or amount of

Table 3

English Glosses for the Twenty-four Stimulus Items Organized Into Sets

Set A	Set E
DRINK	TOILET
CUP	BLANKET
TELEPHONE	COMB
Set B	**Set F**
BABY	PIPE
BED	FOOD
WOMAN	SHOES
Set C	**Set G**
CHILD	BOOK
CAT	WATER
STORE	PENCIL
Set D	**Set H**
MAN	AIRPLANE
COFFEE	APPLE
CLOTHES	EGG

body contact, χ^2 (1, N = 24) = .667, p = .42.

Pictures

The pictured referents of the signs were drawn on separate 3 x 5 inch cards. The written word corresponding to the picture was presented along with the picture on the card (pictures are presented in Appendix D).

Procedure

Translucency Rating Procedure

The mean translucency values used to group 15 of the 24 signs according to high, medium, and low translucency were obtained from Luftig, Page and Lloyd (1983) and Luftig, Lloyd, and Page (1982) . These authors used a rating procedure to obtain translucency values for many signs. Ratings were tallied and averaged for the individual signs. Signs were then rank ordered by mean ratings. For the purposes of this experiment all signs with mean ratings of ≥5.50 were assigned to the high translucency category, those rated ≥3.01 to ≤5.49 were assigned to the medium translucency category, and those rated ≤3.00 were assigned to the low translucency category.

Mean translucency ratings for unimanual versions of bimanual signs (N = 9) were obtained from a pilot study using the procedure presented by Luftig, Lloyd and Page (1982). The subjects were a group of 30 college and graduate students, none of whom had any prior knowledge of ASL signs. The translucency assessment procedure is described in Appendix E.

Procedure For Identifying Signs Involving Body Contact

Two books entitled A Dictionary of American Sign Language (Stokoe, Casterline & Croneberg, 1976) and A Basic Course in Manual Communication (O'Rourke, 1973) were used to determine whether accurate rendering of unimanual signs involved body contact. The determination of whether accurate production of unimanual versions of bimanual signs involved body contact was made by the present author.

Production Complexity Rank Ordering Procedure

All the signs chosen for use in this experiment were analyzed according to the parameters of location, handshape, and movement as described for ASL by Stokoe (Stokoe, Casterline & Croneberg, 1976). In addition to the three parameters proposed by Stokoe et al. (1976) the signs were also analyzed according to a fourth parameter, that of orientation, as suggested by Battison, Markowicz and Woodward (1975). Based on the four individual analyses the 24 signs were assigned a production complexity value. This value was obtained by adding together the values for each of the four components determined to be important in the production of signs (location, handshape, movement, and orientation). In Appendix F are the descriptions of the 24 ASL signs listed according to the parameters location, handshape, movement, and orientation. The production complexity value assigned to each sign, based on the descriptions presented below, is also listed.

For this experiment the 24 signs were separated into one of two categories based on their production complexity value. Signs with production complexity values ≥33.26 were assigned to the high production complexity category and signs with values ≤33.25 were assigned to the low production complexity category (see Table 4).

Handshape (HS). Handshape was analyzed according to a formula developed by Daniloff and Vergara (1984). This formula uses the average age (M) in months at which prehension patterns are produced during development (Dennis et al., 1982) to establish a hierarchy of production difficulty for each handshape used in the production of signs. The formula is as

Table 4

English Glosses of Sign Stimuli Rank Ordered

According to Production Complexity

Low Prod Complexity (≤33.25)		Total Value	High Prod Complexity (≥33.26)		Total Value
1.	SHOES	27.00	13.	PIPE	33.26
2.	BED	27.40	14.	MAN	33.75
3.	COP	28.60	15.	COFFEE	34.00
4.	DRINK	28.60	16.	COMB	34.10
5.	WATER	29.90	17.	TOILET	35.90
6.	BLANKET	30.53	18.	APPLE	36.90
7.	TELEPHONE	30.75	19.	AIRPLANE	37.25
8.	CHILD	30.90	20.	STORE	37.35
9.	FOOD	31.10	21.	CLOTHES	38.00
10.	CAT	31.50	22.	BOOK	40.40
11.	EGG	32.80	23.	PENCIL	40.65
12.	WOMAN	33.25	24.	BABY	45.65

follows: $M_w = M_2 + \frac{1}{4}M_1$; or $M_w = M_3 + \frac{1}{4}M_2 + \frac{1}{2}M_1$ (where $M_3 > M_2 > M_1$). M_w is defined as the weighted developmental value assigned on the basis of the weighted sum of the average age levels at which each component of the handshape is acquired. The weighting is determined by the number of prehension patterns incorporated in the handshape. The rationale used by Daniloff and Vergara (1984) for the ad hoc weighting was based on the assumption that each additional prehension pattern, in handshapes incorporating greater than one prehension pattern, added an additional 25% to the production difficulty of the handshape. Therefore, the weighting for each prehension pattern was determined by adding 25% to the weighting of the previous prehension pattern in the formula. See Table 5 for list of signs organized according to LOC, HS, and MVT.

Location (LOC). Location was judged according to three of the 12 locations in the signing space delineated by Stokoe et al. (1976), face, head, and trunk. These three locations correspond to all the locations for the signs to be used in this study. The three locations were rank ordered in terms of the amount of motor control necessary to place the hand in

Table 5

English Glosses of Sign Stimuli Organized According to Location, Handshape, and Movement

Sign	Location (Tab)	Handshape (Dez)	Movement (Sig)
AIRPLANE	neutral	Y-"horns" hand	pronating rotation/ away
APPLE	cheek	X-hook hand	twisting
BABY*	trunk	B-flat hand	side to side
BED	side-face	B-flat hand	hold
BLANKET*	trunk	B-flat hand	upward/toward
BOOK*	neutral	B-flat hand	supinating rotation
CAT	mid-face	F-"three ring"	leftward
CHILD	neutral	B-flat hand	pronating rotation
CLOTHES*	trunk	5-spread hand	leftward/downward
COFFEE*	neutral	A-fist	circular
COMB	whole head	C-curved hand	downward
COP	trunk	C-curved hand	contact
DRINK	chin	C-curved hand	pronating rotation

continued

(Table 5 continued)

Sign	Location (Tab)	Handshape (Dez)	Movement (Sig)
EGG*	neutral	H-index & second finger, side by side extended	pronating rotation
FOOD	chin	O-tapered hand	toward
MAN	forehead	5-spread hand > O-tapered hand	closing/away
PENCIL*	neutral	X-hook hand	leftward/nodding or bending
PIPE	chin	Y-"horns"hand	away
SHOES*	neutral	A-fist	pronating rotation rightward
STORE*	neutral	O-tapered hand	downward/bending/ away
TELEPHONE	cheek	Y-"horns" hand	toward/hold
TOILET	neutral	T-thumb cross	to-&-fro
WATER	chin	W-3-finger hand	contact
WOMAN	chin > trunk	5-spread hand	downward

<u>Note</u>. Location = place in signing space where sign is made; Handshape = hand configuration used to form sign; Movement = movement involved in making sign. * = bimanual signs produced unimanually.

each location. Based on the suggestion by Daniloff and Vergara (1984) that less control is necessary to place hands in the trunk area compared to the face or head area, the trunk area was predicted to be the easiest location for hand placement and was assigned a location value of 1. The face was predicted to be the next most difficult location and therefore was assigned a location value of 2, followed by the head which was assigned a value of 3.

Movement (MVT). Movement was analyzed according to 17 of the 24 values outlined by Stokoe et al. (1976). Based on data presented by several investigators (Halverson, 1931; Gesell & Amatruda, 1941; Sukiennicki, 1971), Stokoe's 17 values were organized by the present author in terms of a developmental sequence of arm and hand motor pattern development (see Table 6).

Each sign was assigned a movement value based on a formula similar to that used for handshape analysis. The formula is as follows: $M_{wb} = M_{2b} + \frac{1}{4}M_{1b}$ or $M_{wb} = M_{3b} + \frac{1}{4}M_{2b} + \frac{1}{2}M_{1b}$ (where $M_{3b} > M_{2b} > M_{1b}$. M_{wb} is defined as the weighted developmental value assigned on the basis of the weighted sum of the average age levels at which each component of the movement is acquired.

Table 6

Developmental Sequence of Movement Patterns in the Production of Unimanual Signs

Movement Pattens	Age Level	Basis for Decision
1. Movement Toward Signer	1-4 months	Hand to mouth; Object brought toward chest (Sukiennicki,1971; Halverson, 1931; Gesell & Amatruda, 1941)
2. Upward Movement	1-4 months	Hand to mouth (Gesell & Amatruda, 1941)
3. Opening Action	3 months	Hands initially fisted >> open hands (Sukiennicki, 1971)
4. Side to Side Movement	3 months	D. Berman (personal communication, October 8, 1985)
5. Pronating Rotation	4 months	Reaches with palm facing down (Halverson, 1931)
6. Movement Away from Signer	4 months	Hands come out to object (Gesell & Amatruda, 1941)
7. Up and Down Movement	4-5 months	Bangs toy (Gesell & Amatruda, 1941)
8. Leftward Movement	5 months	Arms swing out laterally (Halverson, 1931; Gesell & Amatruda, 1941)

continued

(Table 6 continued)

Movement Pattens	Age level	Basis for decision
9. Rightward Movement	5 months	Arms swing out laterally (Halverson, 1931; Gesell & Amatruda, 1941)
10. Closing Action	5-6 months	Primitive squeeze (Halverson, 1931)
11. To and Fro Movement	7 months	Shakes toy actively and vigorously (Gesell & Amatruda, 1941)
12. Downward movement	7 months	Planing approach begins to be seen (Halverson, 1931)
13. Supinating Rotation	7-12 months	Control supination (Sukiennicki, 1971)
14. Nodding or bending action	9-10 months	Waves and shakes grasped bell (Gesell & Amatruda, 1941)
15. Wiggling action of fingers	9-10 months	Neuromusculature of arms, hand, and digits has attained practically adult value (Halverson, 1931)
16. Twisting movement	12 months	Wrist demonstrates greater flexibility (Halverson, 1931)
17. Circular action	12 months	Wrist demonstrates greater flexibility (Halverson, 1931)

The weighting was determined by the number of motor patterns incorporated in the movement.

Two additional analyses of movement were performed. One examined hand position and the amount of movement required to produce the sign. Signs were determined to either require movement (kinetic) or not to require movement (static). Kinetic signs were felt to be more difficult to produce than static signs. The second analysis of movement categorized signs according to two developmental categories of movement patterns. These categories were the two which pertained to unimanual signs from among seven unimanual/bimanual movement patterns described by Dennis et al. (1982). The mean developmental age at which the two unimanual movement patterns are seen in infants are: (a) 5 months - The arm does not cross the midline of the body, therefore, the sign is made with the arm parallel to the body or at midline, and (b) 9.5 months - The hand crosses the midline of the body or face.

Orientation (HO). Hand orientation was analyzed according to five distinct palm orientations. The notations used to designate the five palm orientations was developed by Daniloff and Vergara (1984) and are presented in Table 7. The developmental age at which

Table 7

Notation For Five Palm Orientations

Orientation	Symbol
Horizontal	
1. Down	$\overline{\vee}$
2. Up	$\underline{\wedge}$
Vertical	
1. Toward Body	|<
2. Away From Body	|>
3. Faces Opposite Side	

Note. From "Comparison Between the Motoric Constraints for Amer-Ind and ASL Sign Formation" by J. K. Daniloff and D. Vergara, 1984, Journal of Speech and Hearing Research, 27, p. 78.

production of each palm orientation becomes possible was determined using research on prehension pattern development (Halverson, 1931; Gesell & Amatruda, 1941; Sukiennicki, 1971; Dennis et al., 1982) (see Table 8). The two horizontal orientations were (a) up (palm to ceiling), and (b) down (palm to floor). The three vertical positions were (a) toward the body, (b) away from the body, and (c) unilateral opposite side (e.g. left palm faces the right).

Sign Training Procedure: Pretraining Period

Informed consent. Prior to the administration of any experimental items subjects were given a careful explanation of the procedures, risks, and benefits associated with the study. The subjects were required to sign a consent form to authorize their own participation in the study. For subjects not legally authorized to represent themselves consent was obtained from the spouse or legal guardian on behalf of the subject. Subjects were given a copy of the consent form to keep (see Appendix G for forms).

Evaluation of sign knowledge. Once eligibility for the study was determined, and all pretests had been administered, subjects were evaluated to confirm that they had no prior knowledge of the 24 signs to be

Table 8

Developmental Sequence for Production of Five Palm Orientations

Palm Orientation Notation	Age Level	Basis for Decision
	4-6 months	Approach hand pronated throughout (Sukiennicki, 1971; Halverson, 1931)
	6 months	D. Berman (personal communication, October 8, 1985)
	8-9 months	Aim of hand in when approaching object (Halverson, 1931)
	10-12 months	Aim of hand at when approaching object (Halverson, 1931)
	12 months	Control supination (Sukiennicki, 1971)

Note. Symbols in column 1 are from "Comparison Between the Motoric Constraints for Amer-Ind and ASL Sign Formation" by J. K. Daniloff and D. Vergara, 1984, Journal of Speech and Hearing Research, 27, p. 78. Adapted by permission.

presented during training.

Presentation of uses of gesture in everyday life. The experimenter gave each subject a presentation of the wide variety of uses of gesture in American life by persons who have command of spoken language. The experimenter discussed the regular use of gesture by: (a) construction workers, (b) sports referees, (c) policemen, (d) sailors, (e) stock market personnel, (f) auctioneers, and (g) television and radio directors. The experimenter had the subjects demonstrate any of the aforementioned gestures they were familiar with.

The experimenter demonstrated some signals in daily use by many people, such as: (a) headshake (yes, no), (b) a shoulder shrug (maybe, perhaps), (c) finger pointing (that person, that thing), (d) an extended hand, palm up (give me), (e) an extended hand, palm out, wrist flexed (stop), (f) finger crooking (come here), (g) finger over lips (quiet, hush).

Training in task relevant instructions. The experimenter trained the subjects to respond to all the task relevant instructions using examples independent from the study.

Sign Training Procedure: Training Period

The subjects were seen for approximately 2 hours (two 60 minute sessions). The two training sessions were separated by one week. Each experimental session focused on the training of four sets of signs. Three signs were included in each set, totaling 12 signs that were presented during each training session. The sets were labeled A through H (see Table 3). The order of sign presentation to subjects was determined by group affiliation. Subjects in groups A and C received training in sets A through D during session one and sets E through H during session two, and for subjects in groups B and D the set order was reversed, E through H in session one, and A through D in session two. The signs were administered in the two different orders, described above, in order to obtain short-term retention data on all signs without having to require subjects to return for a third session.

Three types of trials were administered for each sign: Handshaping and physical guidance trials, test trials, and probe trials. During the handshaping and physical guidance trials the subjects were taught to produce the sign correctly when presented with the pictorial referent. Handshaping and physical guidance training continued until either the sign was produced correctly or four trials had been completed, whichever was achieved first.

Once handshaping trials for the three signs in a set had been completed, receptive and elicited test trials were administered, in that order. Following the tests, the 12 signs trained during the session were probed using the procedures developed for the elicited and receptive tests. One elicited and one receptive sign probe trial was administered for each sign.

At the beginning of the second training session, one week following the first, another probe of the previous session's signs was administered.

All sign training was done with a minimum of verbal input. Training procedures were as follows:

Physical guidance (training). Subjects were trained individually by a female experimenter. The card with the appropriate picture was presented and the experimenter directed the subject's attention to the picture. While the subject was attending to the picture the experimenter molded the subject's hand into the sign's handshape and physically guided the subject's hand through the sign that corresponded to the picture. The subject was then requested to produce the sign unassisted. Positive verbal feedback was provided for correct responses, and correction for errors. A maximum of four physical guidance trials was administered for each sign.

Receptive_signing_(test). The three cards corresponding to the sign set being trained were presented. The experimenter produced a sign corresponding to one of the referents shown and asked the subject to point to the card associated with the sign produced. No reinforcement or feedback was offered during the test. Four receptive signing test trials were administered for each sign. The order of presentation of the trials were randomly determined.

Elicited_signing_(test). The card with the picture of the sign being trained was presented and the subject's attention was directed toward it. The subject was instructed to produce a sign that corresponded to the picture. The experimenter gave the subject 30 seconds within which to respond. No reinforcement or feedback was offered during the test. There were four elicited signing trials for each sign. The order of presentation of the elicited signing trials were randomly determined.

Probe_. Probes were administered using the procedures developed for the elicited and receptive signing tests. At the completion of each of the two training sessions one receptive and elicited signing probe trial was administered for each sign trained. A probe was also administered at the beginning of the second training session for the signs trained at the first training session. No feedback was provided during probe trials.

Scoring Criteria

All training sessions were videotaped allowing the experimenter conducting training to rate each subject's performance through the course of each session. Each of the four components or "parameters" of a sign (handshape, hand orientation, location on the body, and movement) were scored one or zero according to whether or not its production was sufficiently accurate to contribute to the overall comprehensibility of the sign. Fawcett and Clibbens (1983) referred to this method of scoring sign performance as a cheremic two point scale.

The following criteria was used to score sign parameter errors:

1. Handshape errors = the subject produces an incorrect handshape.

2. Hand orientation errors = any deviations from correct orientation of palm and/or fingers.

3. Location errors = the subject produces the sign at an incorrect body location.

4. Movement errors = the sign is produced with an incorrect movement. Touch errors were graded as movement errors.

Movement error types were scored separately using the following criteria:

1. Intrusion errors = the subject produces a response that includes all or part of another sign.

2. Unrelated errors = the sign produced is unrelated to any of the 24 signs being trained.

3. Duplication errors = signs may involve either single or repetitive movement cycles. This error type reflects any multiplication of single cycles or reduction of repetitive cycles to a single movement.

During initial training (handshaping and physical guidance/sign acquisition) the number of handshaping and physical guidance trials required to elicit a correct sign production was recorded for each sign for all subjects. If a sign was performed correctly but was slightly distorted ie. stiff, slow etc. additional training trials were administered to help the subject improve the quality of the sign production. These additional trials were included in the sign training score. The number of additional trials administered did not exceed the maximum of four training trials allotted for each sign.

On the immediate posttraining elicited signing test, the same day elicited signing probe, and the one-week posttraining elicited signing probe, the number of correctly executed parameters was recorded for each sign presented for all subjects. A response was considered correct if all four sign parameters were performed correctly in combination. If a sign was formed correctly except for a contact/no-contact discrepancy, the response was scored as correct except for contact (CEC) (Lloyd Doherty, 1983). Thus, if a sign was taught as a body-contact sign and was produced without the contact dimension or was taught as a non-body-contact sign and was produced with contact added, it would be scored as correct except for contact.

Due to the scoring on the body-contact/ non-body-contact dimension two scores were obtained for each sign produced, a strict score and a lenient score. The strict score was composed of the total number of correctly executed parameters for each sign, the lenient score was composed of the total number of correctly executed parameters except for contact. The reason that the scores were separated is because in rapid signing among fluent signers the contact dimension is sometimes omitted without a significant reduction in intelligibility.

Receptive signing tests, and probes were scored according to whether the picture chosen was correct or incorrect.

Inter-judge Reliability

As a measure of the reliability of the trainer's scoring of each subject's sign productions an independent judge fluent in ASL scored 100% of the elicited signing probe trials from videotape. Inter-judge reliability was determined in two ways, first, a Pearson product moment correlation was computed to determine the degree of relationship between the two scorers evaluations of the subject's correct performance of the 24 signs. The values used in the correlation analysis were obtained by tallying the number of correct responses on each probe and dividing by the number of trials presented (N = 12). The Pearson product moment correlation indicated that agreement between the independent judge and the experimenter on the number of correct responses averaged 85% for the probes administered at the end of the training session (probe 1) and 80% for the probes administered one week following initial training (probe 2).

The second value computed was the mean percent agreement between the two judges on the scoring of the four sign parameters of handshape (HS), hand orientation (HO), location (LOC), and movement (MVT) as correct or incorrect. Table 9 lists the mean percent agreement on scoring between the two judges for each sign collapsed across all probes. This value ranged from 77.94% to 96.25% and the mean was 90.11%.

Table 9

Mean Percent Scoring Agreement for the Twenty-four Signs

Signs	MN % Agreement	Signs	MN % Agreement
AIRPLANE	81.58	DRINK	86.90
APPLE	88.75	EGG	88.24
BABY	89.29	FOOD	91.67
BED	95.24	MAN	92.86
BLANKET	86.90	PENCIL	89.29
BOOK	92.50	PIPE	94.05
CAT	91.25	SHOES	87.50
CHILD	89.29	STORE	86.84
CLOTHES	91.67	TELEPHONE	92.86
COFFEE	92.86	TOILET	90.63
COMB	94.05	WATER	77.94
COP	96.25	WOMAN	94.12

CHAPTER IV

Results

Summary of Pretest Results

Presented below is a brief description of each aphasic subject's performance on the language and gesture pretests. Several pretest scores are presented in Table 10 and Table 11. The Boston Diagnostic Aphasia Examination (BDAE) Z-score profiles and praxis profiles for each aphasic are presented in Appendix H.

Subject JS was rated at severity level "4" on the BDAE Aphasia Severity Rating Scale indicating a mild expressive language impairment. This language impairment was secondary to a CVA that damaged the left fronto-parietal region of the brain. A score of 33 on the Shortened Version of the Token Test indicated a mild auditory comprehension impairment. Gesture production was relatively unimpaired, however the score obtained on the Kimura Movement Copying Test was just at the cut off of 17, indicating impairment on kinetic gestures. Gesture comprehension was generally unimpaired with the obtained score of 29 above the cut-off of 26. JS exhibited a strong desire to communicate.

Table 10

Aphasic Subjects' Language Pretest Results

	Reading Comprehension	Auditory Comprehension			Oral Expression		
	Wd Pict Match	Commands	Complex Material	Short Token Test	Confront Naming	Word Reading	Repetition Words
Subject	Max Score = 10	Max Score = 15	Max Score = 12	Max Score = 36	Max Score = 105	Max Score = 30	Max Score = 10
JS	10	15	10	33.0	102	24	10
AA	10	15	10	28.0	99	30	10
DJ	9	5	8	17.5	101	28	10
RB	10	15	9	31.5	101	30	10
MF	9	3	8	10.5	15	6	9
SS	9	6	7	17.5	72	30	9
EA	10	7	3	10.0	24	6	10
PB	9	15	11	31.5	99	30	10

Table 11

Aphasic Subjects' Praxis Pretest Results

	Gesture Comprehension		Gesture Production					
			Nonrepresentational		Representational			
Subject	Mvt Ident Max Score = 5	Pantomime Recog Max Score = 30	Kimura Hand Posture Max Score = 10	Kimura Mvt Copying Max Score = 24	Buccofacial Max Score = 6	Intrans Limb Max Score = 12	Trans Limb Max Score = 12	Whole Body Max Score = 12
JS	5	29	8	17	5	12	10	11
AA	4	30	9	10 *	6	12	12	12
DJ	4	29	10	16 *	4	11	9.5	9
RB	5	30	10	24	6	12	11	9
MF	5	30	10	19	5	11	12	6
SS	5	29	8	13 *	5	9	8	8
EA	5	30	10	16 *	3	9	12	9
PB	5	30	10	16 *	6	11	12	9

Note. * = impaired performance

Subject AA rated at severity level "4" on the Aphasia Severity Rating Scale, exhibited a mild expressive language impairment characterized by literal and verbal paraphasias. This language impairment resulted from a CVA that damaged the left fronto-parietal cerebral area. Performance on the Shortened Version of the Token Test was slightly impaired indicating mild auditory comprehension difficulty. Gesture production was generally mildly impaired, however, performance on the Kimura Movement Copying Test was severely impaired, indicating severe difficulty with kinetic movements. No difficulty was displayed on gesture comprehension. AA also exhibited a strong desire to communicate.

Subject DJ exhibited a mild to minimal expressive language impairment secondary to a CVA that damaged the left frontal lobe. DJ was rated at severity level "5" on the BDAE. Receptive language, as evaluated by the Shortened Version of the Token Test and various BDAE subtests, was determined to be moderately impaired. Performance on the gesture production subtests revealed moderate to severe impairment. Transitive and whole body movements were also moderately impaired. Gesture comprehension was unimpaired and a strong desire to communicate was displayed by the subject.

RB obtained a level "5" aphasia severity rating on the BDAE indicating a mild to minimal expressive language impairment secondary to a CVA. CT scan revealed damage to the left fronto-parietal region of the brain. Auditory comprehension and gesture comprehension were unimpaired. Evaluation of gesture production via the Kimura Hand Posture and Movement Copying tests, revealed no impairment, although, examination of whole-body movements and hand postures specifically associated with the study revealed slight gesture production impairment.

Subject MF was rated at severity level "1" on the BDAE Aphasia Severity Rating Scale indicating a severe expressive language impairment. MF was diagnosed as exhibiting a mixed nonfluent type of aphasia due to his performance on the BDAE and Shortened Version of the Token Test. This language impairment was secondary to a CVA. CT scan revealed damage to the left fronto-parietal region of the brain. Gesture production was mild to moderately impaired, although, whole-body movements were severely impaired. There was no evidence of gesture comprehension impairment. This subject displayed a strong desire to communicate using gestures.

SS presented with a moderate to severe expressive and receptive language impairment secondary to a CVA. CT scan revealed damage in the left fronto-parietal cerebral area. This subject was rated at severity level "2" on the BDAE and displayed moderate auditory comprehension impairment on the Shortened Version of the Token Test. Based on performance on the BDAE and Shortened Version of the Token Test, SS was diagnosed as exhibiting Broca's aphasia. Gesture production was moderate to severely impaired while gesture comprehension was determined to be unimpaired. Subject SS displayed a moderately strong desire to communicate.

EA received a level "1" rating on the BDAE indicating a severe expressive and receptive language impairment which was secondary to a CVA. CT scan revealed damage in the left fronto-parietal temporal cerebral area. Receptive language impairment was further verified by an extremely poor performance on the Shortened Version of the Token Test. Based on performance on the BDAE and Token test EA was diagnosed as exhibiting a mixed nonfluent aphasia. Gesture production was moderate to severely impaired while transitive movements remained unimpaired. Gesture comprehension was unimpaired and the desire to communicate was determined to be very strong.

FB exhibited a mild to minimal language impairment as evidenced by a BDAE Aphasia Severity Rating of "5". This subjects' language impairment was secondary to a CVA that damaged the left fronto-temporal region of the brain. No auditory or gesture comprehension impairment was evident. Gesture production was in general minimally impaired, however, whole-body movements were moderately impaired. The desire to communicate was very strong.

Missing Data

Due to an unplanned error in training, the data from subject DJ was based on 23 signs as opposed to 24. In order to account for this missing data, mean values were used in the statistical analyses discussed below.

Elicited Signing Results

Very few errors were made on the receptive signing portions of the study. The results of this investigation will therefore be presented as they pertain to each hypothesis, in terms of the elicited signing data only. The receptive signing errors will be discussed separately in the last section of this chapter.

Acquisition

Hypothesis 1 (Acquisition and Brain Injury)

The first hypothesis stated that brain injury (stroke) will result in the need for an increased number of initial training trials (handshaping and physical guidance trials) in order to achieve criterion performance (one adequate sign performance or completion of four training trials), and will result in fewer signs being acquired. To evaluate the effect of brain injury on ASL sign acquisition, the mean number of handshaping and physical guidance trials administered to each subject, and the total number of signs acquired by each subject, were analyzed using a Mann-Whitney U test, the nonparametric alternative to the independent samples t-test (Siegel & Castellan, 1988). The Mann-Whitney U test was used because the sample sizes were small.

Table 12 presents the total and mean number of training trials administered to each subject and the means for both subject groups. A maximum of four trials was administered for each of the 24 signs, resulting in a maximum possible total score of 96 training trials for each subject. It can be seen that the total and mean number of training trials

Table 12

Total and Mean Number of Sign Training Trials

Subject: Aphasics	Total Sign Training Trials Maximum = 96	Mean Sign Training Trials Maximum = 4
JS	64	2.67
AA	52	2.17
DJ[a]	71	3.09
RB	42	1.75
MF	62	2.58
SS	59	2.46
EA	53	2.21
PB	44	1.83
Mean	55.88	2.35[b]
SD	10.00	0.45

continued

(Table 12 continued)

Subject: Controls	Total Sign Training Trials Maximum = 96	Mean Sign Training Trials Maximum = 4
BB	35	1.46
JB	39	1.63
BL	29	1.21
JT	44	1.83
FM	49	2.04
EW	53	2.21
Mean	41.50	1.73[b]
SD	8.94	0.37

Note. Means with same superscript indicate distributions are significantly different at $p < .05$.

[a]This subject received training on 23 signs.

administered to the aphasics were in general larger than the values for the controls, $U = 7.00$, $p = .03$. Shown in Table 13 are the total number of signs acquired by each subject. The difference between the groups on the number of signs acquired just reached significance, $U = 9.00$, $p = .0497$. Therefore, controls acquired significantly more signs than the aphasic subjects.

Hypothesis 2 (Acquisition and Production Complexity)

The second hypothesis stated that for both aphasics and normal controls fewer training trials will be necessary to achieve criterion performance during acquisition of low production complexity (LPC) compared to high production complexity (HPC) signs. The mean number of training trials administered for each sign was analyzed by a 2 (Group) x 2 (Production Complexity) analysis of variance (ANOVA) with repeated measures on the last factor.

Significant main effects were found for the subject groups variable, $F(1, 22) = 24.37$, $p = .0002$, and for production complexity, $F(1, 22) = 12.33$, $p = .0023$. The interaction between the two variables was not significant. As shown in Table 14 the significant main effect for production complexity

Table 13

Total Number of Signs Acquired by Subjects

Subject: Aphasics	Total Signs Acquired	Signs Not Acquired
JS	22	Man, Clothes
AA	24	
DJ[a]	16	Cop, Woman, Cat, Store, Man, Comb, Pencil
RB	24	
MF	21	Comb, Cop, Cat
SS	22	Man, Egg
EA	24	
PB	23	Man
Mean	22.00[b]	
SD	2.67	

continued

(Table 13 continued)

Subject Controls	Total Signs Acquired	Signs Not Acquired
BB	24	
JB	24	
BL	24	
JT	24	
FM	24	
EW	24	
Mean	24.00[b]	
SD	0.00	

Note. Means with same superscript indicate distributions are significantly different at $p < .05$.

[a]This subject received training on 23 signs.

Table 14

Mean Number of Training Trials for High and Low Production Complexity Signs

	Production Complexity	
	High	Low
Aphasics	2.64[a]	2.05[a]
Controls	1.85	1.61

Note. Maximum Score = 4.

Means with same superscript are significantly different at $p < .05$.

indicated that aphasics required significantly fewer training trials on LPC compared to HPC signs.

Since there was differential acquisition of signs only by the aphasics the second hypothesis was partially supported.

Relationship between acquisition and production complexity. One further computation made pertaining to the production complexity feature was that of eta squared (E^2). This statistic is derived from the following formula for eta (E) (Kirk, 1968):

$$E = \sqrt{\frac{\text{Between Groups Sum of Squares}}{\text{Total Sum of Squares}}}$$

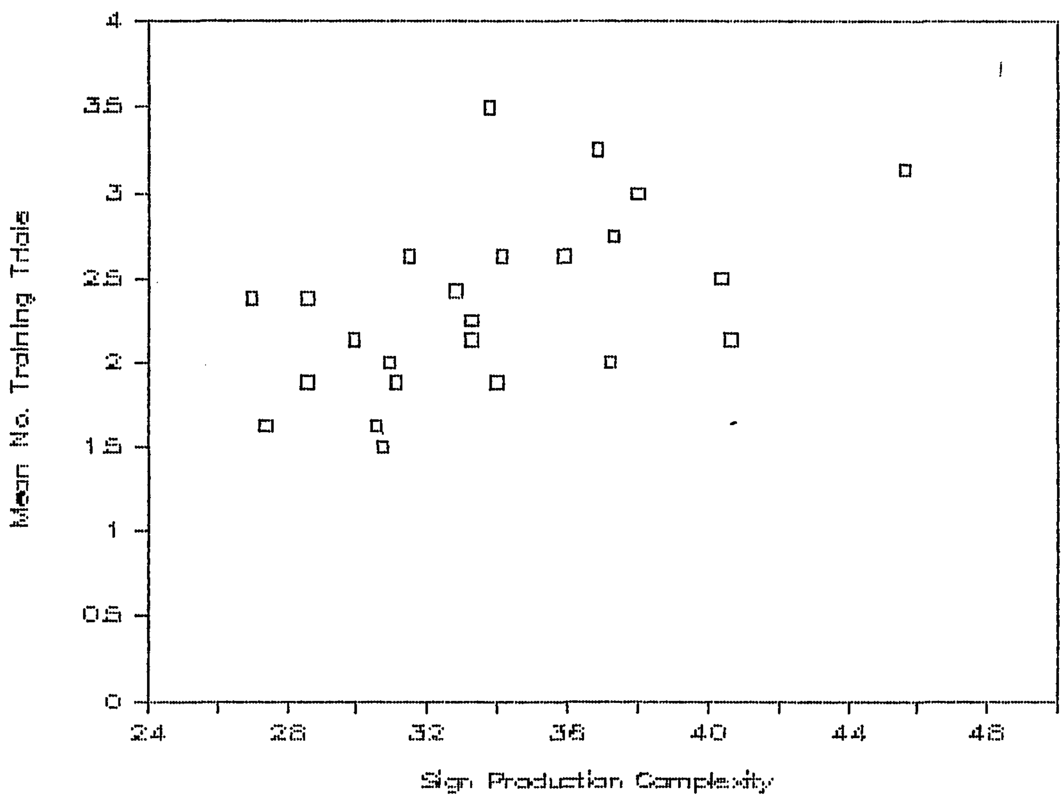
E can be used to describe the degree of relationship between independent and dependent variables and E^2 indicates the proportion of variance in a dependent variable accounted for by the independent variable.

For the production complexity feature an E value of .57 ($E^2 = .33$) was obtained for the aphasics. Eta for the controls was equal to .30 ($E^2 = .09$). Thus, approximately 33% of the variance in sign acquisition by the aphasics may be accounted for by the production complexity feature compared to 9% for the controls. This indicates that the relationship between production complexity and acquisition was much stronger for the aphasics than for the controls.

Since, among the aphasics, the relationship between acquisition and the production complexity feature was determined by eta to be moderately strong, an additional analysis was conducted to provide a more accurate description of the relationship. Presented in Figure 3 is the scatter plot of the relationship between the 24 production complexity values and the mean number of acquisition trials per sign. A Spearman rank order correlation was computed between these two sets of values because (a) the relationship appears linear, and (b) the distribution of production complexity values was determined to have a significant negative skew. The Spearman rank order correlation is a nonparametric alternative to the Pearson product moment correlation and has a 91% efficiency when compared to the Pearson (Siegel & Castellan, 1988).

The value obtained from this analysis was $r_{rank} = .56$, $p = .007$, which represents a moderate but significant correlation that was very close to the E

Figure 3. Scatter plot of relationship between sign production complexity values and number of training trials (acquisition) required by aphasics.


Mean No. Training Trials
0
0.5
1
1.5
2
2.5
3
3.5
4
24
28
32
36
40
44
48
Sign Production Complexity

value of .57 obtained for the relationship between acquisition and production complexity designated according to two discrete levels.

<u>Hypothesis 3 (Acquisition and Body Contact)</u>

The third hypothesis stated that for both aphasics and normal controls fewer trials will be necessary during training of body-contact (+BC) compared to non-body-contact (-BC) signs. The influence of body contact on the number of training trials required during sign acquisition was examined by a 2 (Group) x 2 (Body Contact) analysis of variance with repeated measures on the last factor. A between groups main effect was the only significant effect found $F(1, 22) = 30.83$, $p = .0001$. Since body contact was not shown to influence the number of training trials administered to either the aphasics or normal control subjects, the third hypothesis was not supported.

<u>Hypothesis 4 (Acquisition and Translucency)</u>

The fourth hypothesis stated that for both aphasics and normal controls fewer training trials will be necessary during acquisition of high compared to medium translucency signs, for medium compared to low translucency signs, and for high compared to low translucency signs. The influence of translucency on sign acquisition was examined by a 2 (Group) x 3 (Translucency) ANOVA with repeated measures on the last factor. A significant between groups main effect was the only significant effect found, $F(1, 14) = 32.24$, $p = .0002$. Since no significant differences were found within the subject groups for the training of signs differing in translucency, the fourth hypothesis was not supported.

In summary, the sign feature found to have a strong relationship with acquisition for the aphasics was production complexity. None of the three sign features was found to strongly influence sign acquisition by the controls.

Hypothesis 5 (Acquisition of Parameters)

No prior predictions were made regarding the hierarchy of acquisition for ASL parameters in aphasics and normal controls. This issue was examined for each group of subjects by totaling the number of correct responses produced for each parameter and dividing this value by the total number of training trials administered for all signs. The value obtained from this operation was the proportion of correct responses for each parameter across all signs. The hierarchy of acquisition for ASL parameters will be presented for both subject groups and for the individual aphasic subjects. The four ASL parameters are defined as (a) handshape (HS), (b) hand orientation (HO), (c) location (LOC), (d) movement (MVT).

The relationships between the values for each parameter are graphically presented in Figure 4. These results indicate that the order of acquisition for the four parameters by the aphasic subjects was HO > LOC > HS > MVT; and the order of acquisition by the controls was HS = HO > LOC > MVT. For both aphasics and controls the percent of correct responses produced on the MVT parameter during acquisition was considerably lower than that produced on any of the other parameters. The difference between the percent correct on the movement parameter and the other three parameters was much larger for the aphasics than the controls.

<u>Individual aphasic subjects results</u>. Presented in Table 15 are the values obtained by the eight aphasic subjects for the percent of correct responses associated with each of the four sign parameters. The order of acquisition for the four parameters was the same for only two subjects JS and EA, the remaining six

Figure 4. Percent of correct responses for each parameter during acquisition.

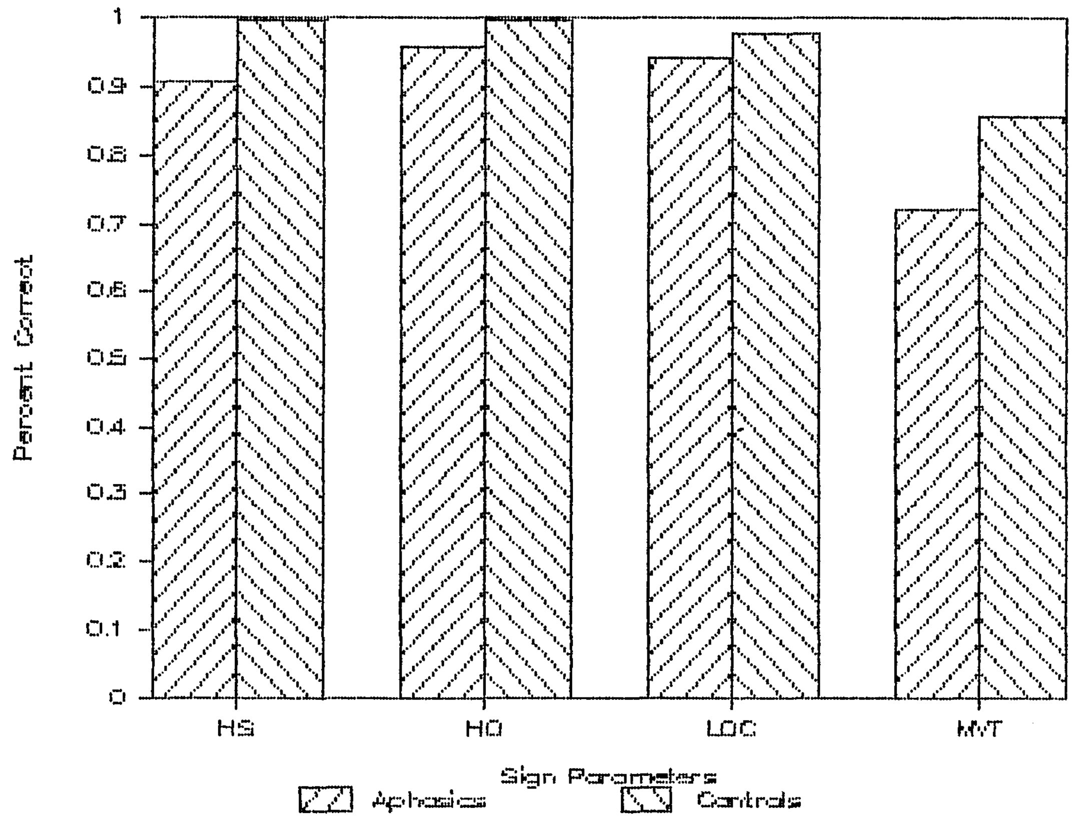

Percent Correct
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
HS
HO
LOC
MVT
Sign Parameters
Aphasics
Controls

Table 15

Percent Correct Responses on Sign Parameters by Individual Aphasic Subjects During Sign Acquisition

Subjects	HS	HO	LOC	MVT	Parameter Order of Acquisition First > Last
JS	89.1	95.3	84.4	67.2	HO > HS > LOC > MVT
AA	94.2	96.2	96.2	86.5	HO = LOC > HS > MVT
DJ	78.9	94.4	88.7	54.9	HO > LOC > HS > MVT
RB	92.9	100	100	95.2	HO = LOC > MVT > HS
MF	91.9	95.2	100	62.9	LOC > HO > HS > MVT
SS	89.8	89.8	98.3	62.7	LOC > HS = HO > MVT
EA	96.2	98.1	92.5	90.6	HO > HS > LOC > MVT
PB	100	100	97.7	70.5	HS = HO > LOC > MVT

subjects acquired the parameters in unique orders, although the general trend was for the hand orientation and/or location parameter to be acquired before the movement and/or handshape parameter. The movement parameter was acquired last by all of the aphasic subjects except RB who acquired the handshape parameter last. Subject SS's acquisition order was also interesting because both the HS and HO parameters were acquired at about the same point in training.

<u>Recall</u>

The results discussed below pertain to the recall data obtained from the subjects at three different time intervals following training (a) immediately following training - immediate posttraining recall (initial test), (b) at the end of the training session - same day recall (probe 1), and (c) one week following training - one week posttraining recall (probe 2). The test and probe 1 data are based on eight aphasics and six controls. During training each of the two subsets examined on the second probe (A through D and E through H) was presented to half of the subjects in each group. Therefore, four aphasic subjects were examined on the signs in subset A through D on probe 2 and four were examined on the signs of subset E through H.

Similarly, on probe 2 three normal controls were examined on the signs comprising subset A through D and three were examined on the signs from subset E through H. Therefore each subject only received a one week posttraining recall probe on the twelve signs trained at the first session.

Hypothesis 6 (Recall and Brain Injury)

The sixth hypothesis stated that brain injury will result in a smaller mean number of sign parameters performed correctly during immediate posttraining recall (test), same day recall (probe 1), and one week posttraining recall (probe 2). Since the two subject groups were small in size the differences between the distributions of scores for the three different recall periods were examined using the Mann-Whitney *U* test.

As shown in Table 16 the mean number of parameters recalled by aphasics was lower than that of controls at all three recall periods. The results of the Mann-Whitney *U* test support the observed differences in performance between the two subject groups. Under both the strict and lenient scoring conditions significant differences were found between the aphasics and controls on the test and probe 1 data, $U_{\text{Test (Strict)}} = 0$, $p = .002$; $U_{\text{probe 1 (Strict)}} = 1.5$,

Table 16

Mean Number of Parameters Recalled by Each Subject

Under Strict and Lenient Scoring Conditions

	Test Maximum Score = 16		Probe 1 Maximum Score = 4		Probe 2 Maximum Score = 4	
Aphasic Subjects	Strict	Lenient	Strict	Lenient	Strict	Lenient
JS	10.04	10.46	2.42	2.42	2.08	2.25
AA	13.08	13.38	2.92	2.96	2.33	2.33
DJ	9.87	10.13	1.92	1.96	2.33	2.33
RB	12.63	13.21	3.21	3.29	2.58	2.58
MF	13.42	13.92	3.00	3.04	0.83	0.83
SS	11.08	11.50	2.13	2.21	2.25	2.42
EA	12.63	12.75	3.04	3.13	1.67	1.92
PB	13.21	13.38	2.67	2.79	1.33	1.33
Mean	12.00[a]	12.34[b]	2.66[c]	2.73[d]	1.93	2.00
SD	1.35	1.36	0.44	0.45	0.56	0.57

continued

(Table 16 continued)

	Test Maximum Score = 16		Probe 1 Maximum Score = 4		Probe 2 Maximum Score = 4	
Control Subjects	Strict	Lenient	Strict	Lenient	Strict	Lenient
BB	13.54	13.96	3.42	3.46	3.50	3.67
JB	14.67	14.67	3.13	3.17	2.00	2.08
BL	15.13	15.42	3.54	3.67	2.50	2.50
JT	14.83	15.04	3.21	3.46	2.17	2.25
FM	15.13	15.13	3.54	3.58	2.42	2.50
EW	14.58	14.75	3.54	3.58	3.00	3.00
Mean	14.65[a]	14.83[b]	3.40[c]	3.49[d]	2.60	2.67
SD	0.54	0.46	0.17	0.16	0.51	0.53

Note. Means with same superscript indicate distributions are signficantly different at $p < .05$.

$\underline{p}$ = .004. The distributions with the probe 2 data were not significantly different from each other, although the differences approached significance, $\underline{U}_{\text{probe 2 (Strict)}}$ = 11, $\underline{p}$ = .09. The strict and lenient scoring results were similar.

Since two of the three distributions were significantly different from each other, the sixth hypothesis is given substantial support. The data therefore, suggest that brain injury results in significantly impaired sign recall, and particularly same day recall.

Hypothesis 7 (Recall and Production Complexity)

The seventh hypothesis stated that for both aphasics and normal controls low production complexity (LPC) signs will be produced with a higher mean number of sign parameters performed correctly than high production complexity (HPC) signs during immediate posttraining recall (test), same day recall (probe 1), and one week posttraining recall (probe 2). The scores obtained by the subjects on the initial recall tests were determined to have a significant negative skew. Therefore, the differences between HPC and LPC signs within each subject group were analyzed by the Wilcoxon matched pairs test. The mean number of correctly performed parameters for the signs administered on probe 1 and probe 2 was analyzed by a 2 (Group) x 2 (Production Complexity) analysis of variance with repeated measures on the last factor.

Table 17 presents the subjects' mean recall scores for both high and low production complexity signs under each scoring condition (strict and lenient). Since the results under the two scoring conditions were similar, only the results scored under the strict condition are discussed below.

None of the analyses of differences between the distributions of mean number of correct parameters per sign of HPC versus LPC yielded significant results. It can be seen that the means for HPC and LPC signs are similar to each other at all three recall periods for both aphasic and control subjects. Since these results do not indicate that HPC signs are more difficult to recall than LPC signs, hypothesis seven was not supported.

Relationship between recall and production complexity. Examination of the relationship between recall on the probes and production complexity was conducted by the computation of eta squared. The results obtained revealed a very weak relationship

Table 17

Mean Recall Scores for High and Low Production Complexity Signs

Under Each Scoring System

	Strict		Lenient	
Group	HPC	LPC	HPC	LPC
		Test		
Aphasics	11.68	12.29	12.18	12.48
Controls	14.67	14.63	14.86	14.67
		Probe 1		
Aphasics	2.50	2.83	2.61	2.85
Controls	3.33	3.46	3.45	3.53
		Probe 2		
Aphasics	1.88	2.00	1.92	2.08
Controls	2.58	2.53	2.72	2.61

between the two variables for both subject groups, and similar results under strict and lenient scoring, $E_{Aphasics} = .22$ ($E^2 = .05$); $E_{Controls} = .16$ ($E^2 = .02$).

Hypothesis 8 (Recall and Body Contact)

The eighth hypothesis stated that for both aphasics and normal controls there will be an increased mean number of sign parameters performed correctly for body contact (+BC) than for non-body-contact (-BC) signs during immediate posttraining recall, same day recall (probe 1), and one week post training recall (probe 2).

The data from the normal controls on the tests was found to have a significant negative skew and therefore both the aphasic and control data were analyzed by nonparametric methods. The Wilcoxon matched pairs test was used to examine the influence of body contact on sign recall. Strict and lenient scores on the two probes were analyzed by a 2 (Group) x 2 (Body Contact) analysis of variance with repeated measures on the last factor.

Immediate posttraining recall (test). Under strict and lenient scoring conditions a significant difference was found for the aphasics on the number of parameters performed correctly for +BC compared to -BC signs, Wilcoxon T_{Strict} = 10.50, p = .02. The control subjects also exhibited a significant difference on +BC compared to -BC signs, Wilcoxon $T_{Lenient = Strict}$ = 7.00, p = .01. The means displayed in Table 18 reveal that significantly more parameters were performed correctly for +BC compared to -BC signs and this was true for both aphasics and controls.

Same day recall (probe 1). The control subjects performed more parameters correctly on +BC compared to -BC signs. No significant difference was found between +BC and -BC signs for the aphasics, although their mean recall scores were in the hypothesized direction. Under strict and lenient scoring conditions significant main effects were found for Group, $F_{Strict}(1, 22)$ = 10.95, p = .003; $F_{Lenient}(1, 22)$ = 11.41, p = .003, and Body Contact, $F_{Strict}(1, 22)$ = 7.90, p = .010; $F_{Lenient}(1, 22)$ = 9.35, p = .006. No significant interactions were found.

Examination of the simple effects associated with the significant main effect for body contact was made by repeated measures ANOVA's. The analysis revealed a significant difference between +BC and -BC signs for the control subjects, $F_{Strict}(1, 11)$ = 11.26, p = .007;

Table 18

Mean Recall Scores for Body-Contact (+BC) and Non-Body-Contact (-BC) Signs Under Each Scoring Condition

	Strict		Lenient	
Group	+BC	-BC	+BC	-BC
		Test		
Aphasics	12.92[a]	11.05[a]	13.34[b]	11.32[b]
Controls	15.17[c]	14.13[c]	15.32[d]	14.33[d]
		Probe 1		
Aphasics	2.77	2.55	2.84	2.62
Controls	3.58[e]	3.21[e]	3.71[f]	3.26[f]
		Probe 2		
Aphasics	1.83	2.02	1.96	2.04
Controls	2.97[g]	2.22[g]	3.08[h]	2.25[h]

Note. Means with same superscript indicate distributions are significantly different at $p < .05$.

$\underline{F}_{Lenient}(1, 11) = 15.14$, $\underline{p} = .003$. The means presented in Table 18 show the direction of the difference.

<u>One week posttraining recall (probe 2)</u>. A significant main effect was found for Group, $\underline{F}_{Strict}(1, 22) = 4.87$, $\underline{p} = .036$; $\underline{F}_{Lenient}(1, 22) = 4.39$, $\underline{p} = .045$ and a significant interaction of Group with Body Contact, $\underline{F}_{Strict}(1, 22) = 6.23$, $\underline{p} = .02$; $\underline{F}_{Lenient}(1, 22) = 4.56$, $\underline{p} = .04$. In order to understand which group means were significantly different and therefore responsible for the observed significant main effect and interaction two one-way ANOVA's were computed. The analyses yielded the results presented in Table 18. Significant differences were found between the aphasics and controls for +BC signs, $\underline{F}_{Strict}(1, 22) = 9.55$, $\underline{p} = .005$; $\underline{F}_{Lenient}(1, 22) = 7.55$, $\underline{p} = .011$. However, recall of the -BC signs was not significantly different between the two subject groups. A significant difference was found between recall of +BC and -BC signs for the controls, $\underline{F}_{Strict} = 7.36$, $\underline{p} = .02$; $\underline{F}_{Lenient} = 6.58$, $\underline{p} = .03$. No significant difference between +BC and -BC signs was found for the aphasic subjects.

The results obtained by both groups of subjects on the immediate posttraining test provide strong support for hypothesis eight. Only the control subjects results on probe 1 and probe 2 support the hypothesis; the aphasics' recall scores were in the predicted direction.

Relationship between recall and body contact. The relationship between recall and body contact was determined by the computation of eta squared (E^2). The results obtained revealed a moderate relationship between the two variables for both subject groups on the initial tests, and strict and lenient results were similar, $E_{Aphasics} = .41$ ($E^2 = .17$); $E_{Controls} = .37$ ($E^2 = .14$). The relationship was also moderate for the controls on the probes, with similar results under both scoring conditions, $E_{Probe\ 1} = .47$ ($E^2 = .22$); $E_{Probe\ 2} = .44$ ($E^2 = .20$). The relationship was very weak for the aphasics on the probes, and strict and lenient results were similar, $E_{Probe\ 1} = .15$ ($E^2 = .02$); $E_{Probe\ 2} = .10$ ($E^2 = .01$).

Hypothesis 9 (Recall and Translucency)

The ninth hypothesis stated that for both aphasics and controls at every posttraining test there will be a positive relationship between the number of parameters performed correctly and each sign's translucency. The influence of translucency on sign recall was examined by both parametric and nonparametric methods. Since the mean recall scores obtained on the tests from the aphasics under lenient scoring were found to be skewed, both the strict and lenient data were analyzed by a Friedman two-way ANOVA by ranks.

All of the control data from the initial tests were found to have a strong negative skew and were also analyzed by a Friedman two-way ANOVA by ranks. For both subject groups the data from the two probes (same-day, and one-week posttraining) were analyzed by a 2 (Group) x 3 (Translucency) ANOVA with repeated measures on the last factor.

Immediate posttraining recall (test). As shown in Table 19 for both aphasics and controls the distribution of mean recall scores across the three levels of sign translucency were not found to be significantly different from each other. Translucency was therefore not a significant factor in sign recall on the initial tests. In order to determine whether the distribution of mean recall scores for the aphasics differed significantly from those of the controls on the tests, Mann-Whitney U's were calculated comparing

Table 19

Mean Recall Scores for High, Medium, and Low Transluency Signs Under Each Scoring Condition

	Strict			Lenient		
Group	High	Medium	Low	High	Medium	Low
			Test			
Aphasics	13.35	11.43	11.18	13.83	11.78	11.37
Controls	14.83	14.25	14.85	15.19	14.35	14.94
			Probe 1			
Aphasics	3.13[a]	2.94[b]	1.92[ab]	3.24[c]	3.00[d]	1.94[cd]
Controls	3.67	3.42	3.10	3.77	3.50	3.19
			Probe 2			
Aphasics	2.78[ef]	1.88[e]	1.13[f]	2.97[gh]	1.91[g]	1.13[h]
Controls	3.08	2.46	2.25	3.21	2.54	2.25

Note. Means with same superscript indicate distributions are significantly different at $p < .05$.

the two subject groups at each level of translucency. The difference between aphasics and controls on sign recall was found to be significant under strict scoring for medium and low translucency signs, $\underline{U}_{Medium} = 6.00$, $\underline{p} = .006$; $\underline{U}_{Low} = 5.51$, $\underline{p} = .006$. Under lenient scoring the distribution of mean recall scores revealed significant differences between aphasics and controls at all three levels of sign translucency, $\underline{U}_{High} = 10$, $\underline{p} = .02$; $\underline{U}_{Medium} = 7.50$, $\underline{p} = .010$; $\underline{U}_{Low} = 5.50$, $\underline{p} = .006$. These results indicate that compared to controls, aphasics demonstrated a significant impairment in sign parameter recall on the immediate posttraining tests for medium and low translucency signs scored strictly, and for high, medium, and low translucency signs scored leniently.

<u>Same day recall probe (probe 1)</u>. Analysis of the mean recall scores on probe 1 revealed a significant main effect for Group, $\underline{F}_{Strict}(1, 14) = 45.55$, $\underline{p} = .0001$; $\underline{F}_{Lenient}(1, 14) = 57.44$, $\underline{p} = .000$, and Translucency, $\underline{F}_{Strict}(2, 28) = 13.42$, $\underline{p} = .0002$; $\underline{F}_{Lenient}(1, 14) = 14.799$, $\underline{p} = .001$. In order to understand these results simple effects were computed.

Within each subject group mean recall scores for high, medium, and low translucency signs were compared.

A significant difference was found for the aphasics between the mean recall scores associated with each of the three levels of translucency, $F_{Strict}(2, 14) = 10.36$, $p = .002$; $F_{Lenient}(2, 14) = 11.872$, $p = .001$. For the control subjects the difference between the means just approached significance, $F_{Strict}(2, 14) = 3.52$, $p = .057$; $F_{Lenient}$ $(2, 14) = 3.59$, $p = .054$. To determine which pairs of means were significantly different for the aphasics, correlated samples t-tests were computed. Significant differences were found between medium and low translucency signs, $t_{Strict}(7) = 2.90$, $p = .02$; $t_{Lenient}(7) = 3.15$, $p = .02$, and between high and low translucency signs $t_{Strict}(7) = 4.72$, $p = .003$; $t_{Lenient}(7) = 4.811$, $p = .002$. However, the difference between high and medium translucency signs was not found to be significant. These results indicate that aphasics recalled significantly more high and medium compared to low translucency signs.

<u>One week posttraining recall (probe 2)</u>. The overall ANOVA on the mean recall scores obtained on probe 2 yielded significant main effects for Group,

$F_{Strict}(1, 14) = 23.83$, $p = .0004$; $F_{Lenient}(1, 14) = 20.68$, $p = .0007$; and Translucency, $F_{Strict}(2, 28) = 8.83$, $p = .001$, $F_{Lenient}(2, 28) = 10.22$, $p = .0007$. Simple effects were computed for each group's data across levels of translucency and significant differences were found for the aphasics, $F_{Strict}(2, 14) = 9.49$, $p = .003$, $F_{Lenient}(2, 14) = 11.39$, $p = .0015$. No significant differences were found for the control subjects. Correlated samples t-tests were computed to determine which pairs of means were significantly different from each other. The results revealed that for the aphasics two of the three means were significantly different from each other. Under both strict and lenient scoring the means for high translucency signs were significantly different from the means of medium translucency signs, $t(7)_{Strict} = 2.30$, $p = .05$, $t(7)_{Lenient} = 2.60$, $p = .03$. Also, the means of high translucency signs were significantly different from the means of low translucency signs, $t(7)_{Strict} = 4.57$, $p = .003$, $t(7)_{Lenient} = 4.96$, $p = .002$. This result indicated that significantly more high translucency signs were recalled compared to those of medium and low translucency.

The group main effect was examined by comparing mean recall scores on probe 2 between aphasics and controls at each level of translucency individually. As shown in Table 19 only the means at the low translucency level were significantly different between aphasics and controls, $F(1, 14) = 7.549$, $p = .015$. The mean recall scores for the aphasics and controls were not significantly different for high and medium translucency signs.

Relationship between recall and translucency. The relationship between recall and translucency was determined by the computation of eta squared (E^2). Since analysis of the test data revealed that translucency was not a significant factor in sign recall on the tests, eta squared was calculated for the probe data only.

1. Probe 1. The aphasics obtained an E value of .71 ($E^2 = .51$) under strict scoring and .75 under lenient scoring ($E^2 = .56$). These results indicate that for the aphasics 51% of the variance in recall on probe 1 could be accounted for by the translucency feature with strict scoring, and with lenient scoring the amount of variance explained is 56%. The E value for the controls under strict and lenient scoring was

.57 (E^2 = .33). These results indicate that on probe 1 under strict and lenient scoring 33% of the control subject's variance in recall could be accounted for by the translucency feature.

2. Probe 2. On probe 2 under strict scoring the aphasics E value was .74 (E^2 = .55), indicating that 55% of the variance in recall could be accounted for by the translucency feature. Under lenient scoring the E value for the aphasics was .76 (E^2 = .58), indicating that 58% of the variance in recall on probe 2 could be accounted for by the translucency feature.
Under strict scoring the E value for the controls on probe 2 was .42 (E^2 = .18), and under lenient scoring the E value was .44 (E^2 = .20). Thus, with strict and lenient scoring 18% of the variance in recall performance on probe 2 could be accounted for by the translucency feature.

The relationship between translucency and recall was determined to be very strong for the aphasics on probes 1 and 2, and moderately strong for the controls on probe 1. In order to provide an additional description of these relationships Pearson product moment correlations were computed to indicate the degree of linear relationship between the two variables. The values obtained for r were as follows: r (probe 1, aphasics) = .56; r (probe 1, controls) = .57, r (probe 2, aphasics) = .68. Presented in Figure 5 is the scatter plot of the relationship between the 24 translucency values and the mean number of parameters performed correctly on probe 1 under strict scoring for the aphasics. The scatter plot with the same relationship for the controls is presented in Figure 6. Presented in Figure 7 is the scatter plot of the aphasic data for the relationship between the 24 translucency values and the mean number of parameters performed correctly on probe 2 under strict scoring. Since the relationships in these three figures appear nonlinear the Pearson correlations were supplemented with eta (E) values. Besides its usefulness in describing the extent of the relationship between independent and dependent variables eta is a general index of correlation particularly adapted to data where the relationship between variables is nonlinear (Guilford, 1965). The E values obtained were essentially the same as the Pearson values. The F test of linearity was conducted to determine if the degree to which these regression lines were nonlinear was significant. None of the F

Figure 5. Scatter plot of relationship between mean translucency and mean number of correct parameters on probe 1 for aphasics (strict scoring).

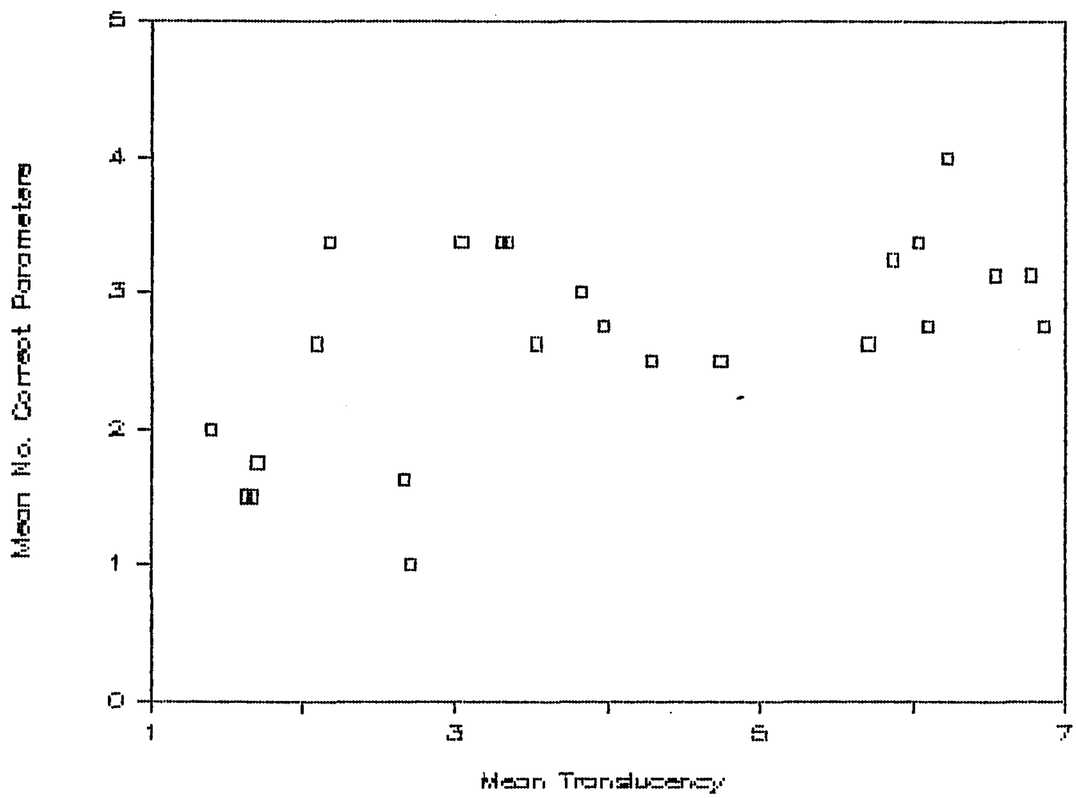

Mean No. Correct Parameters
0
1
2
3
4
5
Mean Translucency
1
3
5
7

Figure 6. Scatter plot of relationship between mean translucency and mean number of correct parameters on probe 1 for controls (strict scoring).

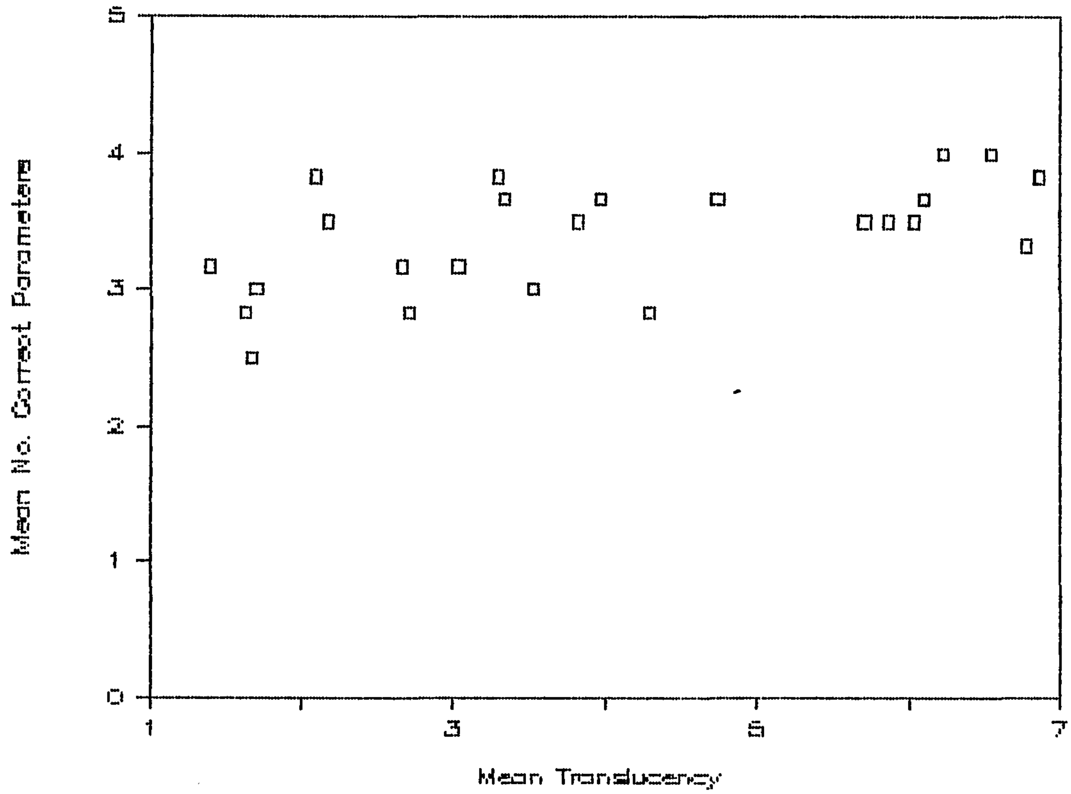
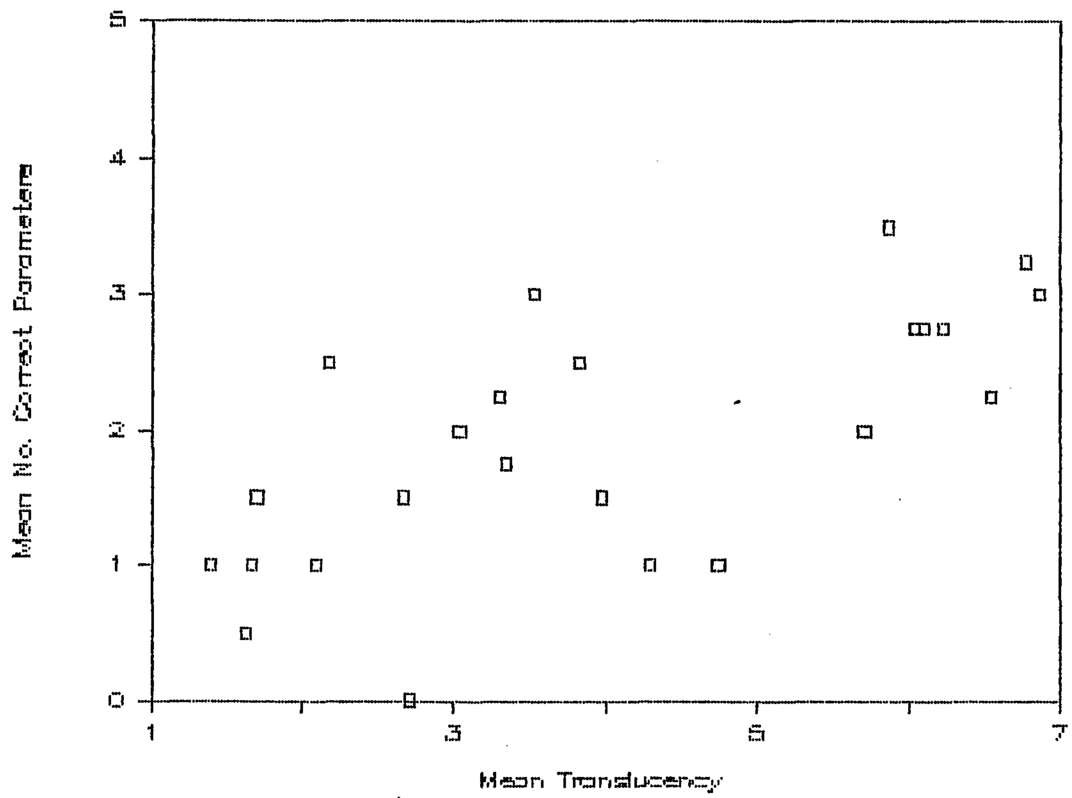

Mean No. Correct Parameters
0
1
2
3
4
5
1
3
5
7
Mean Translucency

Figure 7. Scatter plot of relationship between mean translucency and mean number of correct parameters on probe 2 for aphasics (strict scoring).


5
4
3
2
1
0
Mean No. Correct Parameters
1
3
5
7
Mean Translucency

values obtained from this analysis were significant (F = .05 for all three regression lines, must be > 2.03 to be significant at .05 level). It was concluded, for all three regression lines, that the difference between eta (E) and the Pearson r was not large enough to suggest nonlinearity. Therefore, the Pearson r value adequately describes the relationship between recall scores and translucency values.

In summary, both body contact and translucency were found to influence various aspects of sign recall in the two subject groups. On the initial tests the relationship between body contact and recall was moderate for both groups. On the probes the relationship between translucency and recall for the aphasics was found to be much stronger than the relationship between body contact and recall. In comparison, for the controls a moderate relationship was found between recall and both translucency and body contact.

<u>Hypothesis 10 (Movement Errors and Brain Injury)</u>

The tenth hypothesis stated that brain injury will result in an increased mean number of movement errors being produced during post training tests. To examine this hypothesis the number of movement errors produced by aphasics and controls on the three different recall evaluations was compared by the Mann-Whitney $\underline{U}$ test.

Intrusion errors, unrelated errors and local errors were the movement errors examined. Intrusion errors were responses that included all or part of another sign, unrelated errors were responses that were unrelated to any of the signs trained, and duplication errors were signs produced with multiplication or reduction of correct movement cycles.

The means presented in Table 20 reveal the differences in amount of movement errors produced by the two subject groups at the three recall periods. The statistical analysis yielded significant differences between aphasics and controls on the initial tests, $\underline{U} = 5.50$, $\underline{p} = .02$, and probe 1, $\underline{U} = 8.00$, $\underline{p} = .04$. These results indicate that the aphasic subjects produced significantly more movement errors on the initial tests and probe 1 than the controls. The subjects did not differ however, on the number of movement errors produced on probe 2. Thus, aphasics and controls both produced movement errors during recall, although on the tests and probe 1 aphasics produced significantly more

Table 20

Mean Number of Movement Errors on Recall Evaluations For Each Subject Group

	Test	Probe 1	Probe 2
		Aphasics	
M	6.75[a]	1.79[b]	0.96
SD	9.35	1.50	1.08
		Controls	
M	2.67[a]	1.00[b]	0.61
SD	3.60	1.28	0.78

Note. Means with same superscript indicate distributions are significantly different at $p < .05$.

movement errors than controls.

The mean number of each of the three types of movement errors produced by the two subject groups during the three recall evaluations are presented in Table 21. Analysis of the individual distributions revealed that there was a significant difference between the aphasics and controls on duplication errors produced on the tests, $\underline{U} = 7.50$, $\underline{p} = .03$, and probe 1, $\underline{U} = 6.00$, $\underline{p} = .02$. The remaining distributions were not significantly different from one another. Therefore, the significant differences in movement errors observed between aphasics and controls on the initial tests and probe 1 were due to the increased number of duplication errors produced by the aphasics. These results indicate that aphasics were more likely than controls to multiply or reduce movement cycles when producing signs on the tests and first probes. Although significant differences were not found between the aphasics and controls on unrelated errors and intrusion errors the trend was for aphasics to produce more of each of those two types of errors as well, during recall.

Hypothesis ten was supported by the results from the tests and probe 1 but not by the probe 2 data.

Table 21

Mean Number of Three Types of Movement Errors Produced During Recall

Mov Error	Test	Probe 1	Probe 2
		Aphasics	
Intrusion	3.63	1.75	0.63
Unrelated	0.50	0.50	1.25
Duplication	16.13[a]	3.13[b]	1.00
		Controls	
Intrusion	2.33	2.00	1.00
Unrelated	0.00	0.00	0.33
Duplication	5.67[a]	1.00[b]	0.50

Note. Means with same superscript indicate distributions are significantly different at $p < .05$.

Hypothesis 11 (Movement Error Types Produced During Recall)

No prior predictions were made regarding the proportion of three different types of movement errors (intrusion errors, unrelated errors, and duplication errors) that individual subject groups or individual subjects would produce during recall. To examine this issue the proportion of each type of movement error produced by each of the two subject groups during recall was calculated. The calculation procedure involved dividing the total number of errors associated with each of the three error types by the total number of movement errors produced. The value obtained was the percent of total errors attributed to each type of movement error. As shown in Table 22 duplication errors were proportionally the most common for both aphasics and controls on the tests. The number of unrelated errors, though small on the tests and probe 1, was considerably higher on probe 2 for both subject groups. On all three recall evaluations the proportion of intrusion errors produced by controls was larger than that produced by aphasics. Additionally, the probe 2 data indicate that movement errors produced by aphasics were more likely to be gestures that were

Table 22

Percent of Three Types of Movement Errors Produced During Recall

Mvt Error	Test	Probe 1	Probe 2
		Aphasics	
Intrusion	17.9	32.6	21.7
Unrelated	2.5	9.3	43.5
Duplication	79.6	58.1	34.8
		Controls	
Intrusion	29.2	66.7	54.5
Unrelated	0.0	0.0	18.2
Duplication	70.8	33.3	27.3

unrelated to any that were trained while controls were more likely to incorporate a portion of another sign from the 24 being trained.

Individual aphasic subjects results. Presented in Table 23 are the percentages associated with each movement error type produced during recall by the individual aphasic subjects. As indicated in Table 23, on the initial test most of the aphasics' movement errors were duplication errors, however, subject EA produced proportionally more intrusion errors than any other error type. On probe 1 duplication errors were again the major error type produced by most aphasics. The performance of subjects SS and EA differed from the other aphasics because they produced a much larger proportion of intrusion errors than the majority of aphasics (SS - 57%, EA - 50%). Another unusual performance was that of Subject PB who produced an equal number of unrelated errors and duplication errors on probe 1.

Prior to probe 2 the proportion of unrelated errors remained relatively small for most aphasics. However, on the second probe subjects DJ, RB, and MF produced an unusually large proportion of unrelated errors. For subject EA the largest proportion of

Table 23

Percent of Each Movement Error Type Produced During Recall by Individual Aphasic Subjects

Subject	Test	Probe 1	Probe 2
	Intrusion Errors		
JS	8.7	28.6	0.0
AA	0.0	28.6	0.0
DJ	18.2	25.0	0.0
RB	0.0	20.0	0.0
MF	6.7	28.6	0.0
SS	19.5	57.1	66.7
EA	76.9	50.0	50.0
PB	46.2	0.0	1.0
	Unrelated Errors		
JS	13.0	14.3	50.0
AA	0.0	14.3	0.0
DJ	9.1	25.0	1.0
RB	0.0	0.0	75.0
MF	0.0	0.0	1.0

continued

(Table 23 continued)

Subject	Test	Probe 1	Probe 2
	Unrelated Errors		
SS	0.0	0.0	0.0
EA	0.0	0.0	25.0
PB	0.0	50.0	0.0
	Duplication Errors		
JS	78.3	57.1	50.0
AA	1.0	57.1	1.0
DJ	72.7	50.0	0.0
RB	1.0	80.0	25.0
MF	93.3	71.4	0.0
SS	80.5	42.9	33.3
EA	23.1	50.0	25.0
PB	53.8	50.0	0.0

movement errors on probe 2 was again the intrusion type.

Hypothesis 12 (Recall and Parameter Errors)

No prior predictions were made regarding the hierarchy of parameter errors produced during recall of ASL signs in aphasics and normal controls. The hierarchy of parameter errors exhibited by aphasics and normal controls during sign recall was examined by computing the percent of total errors associated with each of the four parameters: handshaping (HS), hand orientation (HO), location (LOC), and movement (MVT), for the 24 signs trained to subjects. This percent was obtained by totaling across all signs and all subjects in each of the two subject groups the number of errors produced for each of the four sign parameters. The value obtained for each parameter was then divided by the total number of errors summed across all four parameters. The numbers used in this analysis were obtained from recall trials on which subjects produced a response. The features common to signs where no recall response was produced ("no response" signs) are discussed in the subsidiary analyses section.

Group results. The percents computed to determine the hierarchy of parameter errors exhibited by aphasics and controls on the recall test and probes are presented in Table 24.

The highest percent of parameter errors produced by the aphasic subjects was on the handshape parameter. As seen in Table 24 handshape errors were the largest percent of errors under strict and lenient scoring for all three recall evaluations. Control subjects produced their largest percent of movement parameter errors under strict scoring and under lenient scoring the largest percent error was on the handshape parameter. On all three recall evaluations the percent error produced by both aphasics and controls was generally lower for the location parameter. However, on probe 2 the percent error produced by aphasics was lowest on the hand orientation parameter.

The order of recall for the four sign parameters are presented separately for each subject group in Table 24. The parameter recall order for aphasics on the test and probe 1 was LOC > HO > MVT > HS. Between the administration of probe 1 and probe 2 the percent of recall errors on the location parameter increased for the aphasics from 12% to 18%, although the percent of errors on the other three parameters did not change very dramatically.

Table 24

Percent Error on the Four Sign Parameters By Aphasics and Controls

Recall	Scoring	HS	HO	LOC	MVT	Parameter Recall Order First > Last
				Aphasics		
Test						
	Strict	38.1	14.7	10.5	36.6	LOC > HO > MVT > HS
	Lenient	42.8	16.5	11.8	28.9	LOC > HO > MVT > HS
Probe 1						
	Strict	36.1	16.5	11.9	35.6	LOC > HO > MVT > HS
	Lenient	38.5	17.6	12.6	31.3	LOC > HO > MVT > HS
Probe 2						
	Strict	33.3	17.4	18.1	31.3	HO > LOC > MVT > HS
	Lenient	35.0	18.2	19.0	27.7	HO > LOC > MVT > HS

continued

(Table 24 continued)

Recall	Scoring	HS	HO	LOC	MVT	Parameter Recall Order First > Last
				Controls		
Test						
	Strict	33.7	17.6	7.3	41.5	LOC > HO > HS > MVT
	Lenient	39.2	20.5	8.4	31.9	LOC > HO > MVT > HS
Probe 1						
	Strict	32.5	14.5	12.0	41.0	LOC > HO > HS > MVT
	Lenient	38.6	17.1	14.3	30.0	LOC > HO > MVT > HS
Probe 2						
	Strict	35.6	15.1	12.3	37.0	LOC > HO > HS > MVT
	Lenient	38.2	16.2	13.2	32.4	LOC > HO > MVT > HS

The order of parameter recall by the control subjects was influenced by the removal of touch errors from the scoring (lenient scoring). Under strict scoring the order of recall was LOC > HO > HS > MVT and under lenient scoring the order was LOC > HO > MVT > HS. This result indicates that when touch errors are removed from the scoring of movement errors the percent of total parameter errors accounted for by movement becomes lower than the percent accounted for by handshape. Thus, compared to the aphasics a larger proportion of the movement parameter errors produced by the control subjects were touch errors.

Individual aphasic subjects results. The individual subject data will be presented as it relates to each of the three recall evaluations.

1. Test. Shown in Table 25 are the percent error scores obtained by the individual aphasic subjects on the four sign parameters. For most of the eight subjects the percent error score on the hand orientation and location parameters was lower than that on the handshape or movement parameters. Subject SS's performance on the test was very different from the others. This subject produced a higher percent of hand orientation errors than any of the other aphasics.

Table 25

Percent Error on the Four Sign Parameters

by Individual Aphasic Subjects: Test Data

Subject	Scoring	HS	HO	LOC	MVT	Parameter Recall Order First > Last
JS	Strict	32.3	15.6	15.6	36.5	HO = LOC > HS > MVT
	Lenient	36.5	17.6	17.6	28.2	HO = LOC > MVT > HS
AA	Strict	47.1	8.6	17.1	27.1	HO > LOC > MVT > HS
	Lenient	52.4	9.5	19.0	19.0	HO > LOC = MVT > HS
DJ	Strict	40.3	21.6	10.1	28.1	LOC > HO > MVT > HS
	Lenient	42.4	22.7	10.6	24.2	LOC > HO > MVT > HS
RB	Strict	43.2	4.9	9.9	42.0	HO > LOC > MVT > HS
	Lenient	52.2	6.0	11.9	29.9	HO > LOC > MVT > HS
MF	Strict	19.6	19.6	0.0	60.9	LOC > HO = HS > MVT
	Lenient	26.5	26.5	0.0	47.1	LOC > HO = HS > MVT
SS	Strict	22.2	27.8	12.5	37.5	LOC > HS > HO > MVT
	Lenient	25.8	32.3	14.5	27.4	LOC > HS > MVT > HO
EA	Strict	58.0	2.0	8.0	32.0	HO > LOC > MVT > HS
	Lenient	61.7	2.1	8.5	27.7	HO > LOC > MVT > HS
PB	Strict	28.6	8.6	2.9	60.0	LOC > HO > HS > MVT
	Lenient	32.3	9.7	3.2	54.8	LOC > HO > HS > MVT

Follow-up of SS's performance on probe 1 and probe 2 (see Table 26 and Table 27) reveals that hand orientation errors did not continue to be comparatively frequent relative to the other subjects.

The results of two other subjects MF and PB were also different from those of the other six aphasics. These two subjects produced a relatively small number of location parameter errors (MF = 0 (Strict and Lenient); PB = 2.9% (Strict), 3.2% (Lenient)) and a comparatively large number of movement parameter errors (MF = 60.9% (Strict), 47.1% (Lenient); PB = 60% (Strict), 54.8% (Lenient)). Between the two subjects the high percentage of movement parameter errors produced under lenient scoring was primarily on ten individual signs (AIRPLANE, BOOK, COFFEE, COMB, PENCIL, STORE, APPLE, MAN). Eight of these ten signs are high production complexity signs.

As shown in Table 25 the percent errors obtained by subject MF on the handshape and hand orientation parameters were equal, while for the other subjects the hand orientation value was substantially lower than the handshape value.

2. <u>Probe 1</u>. The percent of parameter errors on probe 1 (see Table 26) indicates that for five of the

Table 26

Percent Error on the Four Sign Parameters

by Individual Aphasic Subjects: Probe 1 Data

Subject	Scoring	HS	HO	LOC	MVT	Parameter Recall Order First > Last
JS	Strict	30.8	19.2	15.4	34.6	LOC > HO > HS > MVT
	Lenient	32.0	20.0	16.0	32.0	LOC > HO > HS = MVT
AA	Strict	34.6	19.2	19.2	26.9	HO = LOC > MVT > HS
	Lenient	36.0	20.0	20.0	24.0	HO = LOC > MVT > HS
DJ	Strict	40.4	21.3	10.6	27.7	LOC > HO > MVT > HS
	Lenient	43.2	22.7	11.4	22.7	LOC > HO > MVT > HS
RB	Strict	47.4	5.3	5.3	42.1	HO = LOC > MVT > HS
	Lenient	52.9	5.9	5.9	35.3	HO = LOC > MVT > HS
MF	Strict	20.0	15.0	15.0	50.0	HO = LOC > HS > MVT
	Lenient	21.1	15.8	15.8	47.4	HO = LOC > HS > MVT
SS	Strict	37.9	20.7	10.3	31.0	LOC > HO > MVT > HS
	Lenient	40.7	22.2	11.1	25.9	LOC > HO > MVT > HS
EA	Strict	54.5	0.0	0.0	45.5	HO = LOC > MVT > HS
	Lenient	66.7	0.0	0.0	33.3	HO = LOC > MVT > HS
PB	Strict	25.0	12.5	12.5	50.0	HO = LOC > HS > MVT
	Lenient	30.8	15.4	15.4	38.5	HO = LOC > HS > MVT

Table 27

Percent Error on the Four Sign Parameters

by Individual Aphasic Subjects: Probe 2 Data

Subject	Scoring	HS	HO	LOC	MVT	Parameter Recall Order First > Last
JS	Strict	26.3	21.1	21.1	31.6	HO = LOC > HS > MVT
	Lenient	29.4	23.5	23.5	23.5	HO = LOC = MVT > HS
AA	Strict	25.0	37.5	0.0	37.5	LOC > HS > HO = MVT
	Lenient	25.0	37.5	0.0	37.5	LOC > HS > HO = MVT
DJ	Strict	40.0	20.0	10.0	30.0	LOC > HO > MVT > HS
	Lenient	40.0	20.0	10.0	30.0	LOC > HO > MVT > HS
RB	Strict	47.1	17.6	11.8	23.5	LOC > HO > MVT > HS
	Lenient	47.1	17.6	11.8	23.5	LOC > HO > MVT > HS
MF	Strict	31.8	22.7	18.2	27.3	LOC > HO > MVT > HS
	Lenient	31.8	22.7	18.2	27.3	LOC > HO > MVT > HS
SS	Strict	28.6	14.3	19.0	38.1	HO > LOC > HS > MVT
	Lenient	31.6	15.8	21.1	31.6	HO > LOC > HS = MVT
EA	Strict	25.0	10.0	35.0	30.0	HO > HS > MVT > LOC
	Lenient	29.4	11.8	41.2	17.6	HO > MVT > HS > LOC
PB	Strict	50.0	0.0	12.5	37.5	HO > LOC > MVT > HS
	Lenient	50.0	0.0	12.5	37.5	HO > LOC > MVT > HS

eight aphasic subjects the hand orientation and location parameters were recalled equally well followed by either movement or handshape. Thus, the order of recall by 63% of the aphasics on probe 1 was different from the overall aphasic group performance.

The percent error obtained by subjects RB and EA on the hand orientation and location parameters was considerably lower than that of the other subjects. Subject EA produced no hand orientation or location parameter errors on any probe 1 administered, and subject RB produced a comparatively small percent of hand orientation and location parameter errors on these probes. Conversely these two subjects produced comparatively more handshape parameter errors than the other subjects.

The results in Table 26 also indicate that subject MF and PB again produced comparatively more movement errors than any of the other aphasic subjects.

3. Probe 2. As shown in Table 27 the individual aphasic subjects' performances on probe 2 reveal an order of recall similar to that on the tests; the percent error on the location and/or hand orientation parameters was lower than that obtained on the movement and/or handshape parameters. Thus, for most subjects

the hand orientation and/or location parameter was recalled better than the handshape and/or movement parameter. Under lenient scoring subject JS produced an equivalent proportion of errors on the hand orientation, location, and movement parameters resulting in a very different order of recall than the other subjects: HO = LOC = MVT > HS.

In summary, the percent error obtained for each of the four sign parameters on the three recall evaluations allowed the ranking of parameters in terms of recall order from first to last. The general order for both aphasics and controls was HO and/or LOC followed by MVT and/or HS. Examination of individual aphasic subject data revealed that some aphasics exhibited orders of recall that varied from the general order.

Hypothesis 13 (Relationship Between Gestural Deficit and Apraxia or Modality Deficit)

The thirteenth hypothesis states that the gestural deficit observed among aphasics during acquisition and recall will be largely attributable to a coexisting apraxia or modality deficit. In order to address this issue the relationship between praxis and sign production was examined by correlating performance on the immediate post training recall test (test), same day recall probe (probe 1), and one week posttraining recall probe (probe 2) with performance on six different praxis subtests from the apraxia battery presented in Appendix B. The Spearman rank order correlation method was applied to the score distributions of the five praxis subtests because they were determined to be significantly negatively skewed.

The correlations obtained by the aphasic subjects between the expressive gesture subtests and acquisition and recall scores are presented in Table 28. A strong positive relationship was found between the mean recall score obtained on the initial tests and the apraxia subtest that examined transitive (object use) movements, $r_{s\ (Strict)} = .845$, $p = .02$; $r_{s\ (Lenient)} = .816$, $p = .03$. A strong relationship was also found between performance on probe 1 and the transitive movements apraxia subtest, $r_{s\ (Strict\ =\ Lenient)} = .679$, $p = .07$. These results indicate that transitive movements are strongly related to the number of sign parameters performed correctly both immediately following training (initial test) and at the end of the training session (probe 1).

Table 28

Correlations Between Praxis Subtests and Sign Acquisition and Recall Scores (Strict Scoring)

	Acquis[a]		Recall[b]	
Subtest	Training	Test	Probe 1	Probe 2
Kimura Hand	-.09	.45	.52	-.01
Kimura Movement	.00	.13	-.48	.08
Buccofacial	-.62	.51	.29	.28
Intransitive	-.13	.08	.23	.48
Transitive	-.38	.85	.68	-.38

Note. [a]Number of training trials.

[b]Number of correct sign parameters.

Relationship between gestural deficit and modality deficit. A Pearson product moment correlation was used to examine the relationship between aphasic gestural deficits, as measured by the recall tests and probes, and spoken language deficits, as measured by the visual confrontation naming and word reading subtests from the Boston Diagnostic Aphasia Examination (BDAE). As shown in Table 29 the relationship between probe 2 and visual confrontation naming was strong, $r_{Strict} = .69$, $p = .06$; $r_{Lenient} = .61$, $p = .11$; and a similar relationship was found between word reading and probe 2, $r_{Strict} = .68$, $p = .06$; $r_{Lenient} = .61$, $p = .11$.

Since errors on transitive movements were found to be strongly related to recall of signs both immediately following training and at the end of the training session it can be concluded that the gestural deficit observed among aphasics at these two recall points may be attributable to a specific ideomotor apraxia for transitive movements. The lower negative correlations found between the visual confrontation naming and word reading BDAE subtests and sign recall on the tests and probe 1 do not provide convincing evidence that a modality deficit may be responsible for the aphasics' observed gestural deficit.

Table 29

Correlations Between Selected Expressive Language Subtests and Sign Acquisition and Recall Scores (Strict Scoring)

	Acquis[a]		Recall[b]	
Subtest	Training	Test	Probe 1	Probe 2
Confront Naming	-.10	-.41	-.36	.69
Word Reading	-.18	-.31	-.40	.68
Repetition Wds	-.24	-.11	.13	.40

Note. [a]Number of training trials.

[b]Number of correct sign parameters.

The relationship between receptive performance at the three posttraining recall intervals and receptive language subtests for reading comprehension and auditory comprehension, was not examined statistically because subjects made too few errors to allow such analysis.

Receptive Signing Results

Since very few receptive signing errors were made by the aphasic subjects and none were made by the controls, the receptive signing data was not statistically analyzed. In this study a receptive signing error was defined as the choice of an incorrect picture as the referent for a sign produced by the experimenter. In the discussion to follow the receptive errors made by individual aphasic subjects will be described.

The four aphasic subjects who made receptive signing errors were SS, RB, DJ, and JS. Subject SS made two receptive errors, one occurred when a picture of food was chosen as the referent for the sign SHOES, and the other occurred when a picture of a book was chosen as the referent for the sign PENCIL. No relationship was found between SS's elicited signing errors and these receptive errors.

The receptive errors produced by subject RB all involved the signs STORE and CHILD. On the four receptive signing test trials where the CHILD sign was produced by the experimenter RB chose the picture of a store as the referent for CHILD. This same error occurred on probe 1. A related error was found on RB's probe 1 elicited signing performance of the sign STORE. The STORE sign was made with the HS from the CHILD sign.

Subject JS made receptive errors on the signs STORE, and TOILET. On both probes 1 and 2 JS chose the picture of a cat as the referent for the sign STORE. Another error occurred when the picture of a comb was chosen as the referent for the TOILET sign. No relationship was found between JS's elicited signing performances and these receptive errors.

Subject DJ made one receptive signing error. The picture of an egg was chosen as the referent for the sign AIRPLANE.

In total there were six signs on which aphasic subjects made receptive errors, these were: SHOES, PENCIL, CHILD, AIRPLANE, STORE, TOILET. In relationship to the three variables, translucency, production complexity, and body contact the six signs can be characterized as follows: (a) all six signs are non-body-contact signs, (b) four of the six signs are high production complexity signs, and (c) three signs are high and three are low translucency signs.

Subsidiary Analyses

Influence of Sign Training Order on Mean Recall Scores

Signs were presented to all subjects in the same random order during training. In order to examine the influence of a sign's position during training on the mean recall scores obtained on the probes, Pearson product moment correlation coefficients were computed. Signs in each of the two subgroups trained during the two experimental sessions were assigned a value between 1 and 12 corresponding to its training position. The correlation computed was based on the relationship between each sign's training position and the mean recall score obtained for the sign on the two probes.

Table 30 lists all the computed values for the Pearson $\underline{r}$. Examination of the $\underline{r}$ values reveals that all of the relationships between recall scores on probe 1 and the training position of signs were weak and nonsignificant. The relationships between the probe 2 recall scores and sign training order were all negative, and two of the six correlations were

Table 30

Correlations Between Sign Training Order and Recall Probe Performance for Each Subject Group

Scoring:	Strict		Strict		Lenient		Lenient	
Sign Set:	A - D		E - H		A - D		A - D	
Subj:	Aphasics	Controls	Aphasics	Controls	Aphasics	Controls	Aphasics	Controls
Sign Train Order (Probe 1)	.10	-.24	-.04	.18	-.02	-.35	-.07	.08
Sign Train Order (Probe 2)	-.38	-.62	-.15	-.37	-.41	-.59	-.15	-.40

moderately high. The moderately high correlations were obtained from the normal control subjects on the probe 2 which evaluated the signs from sets A through D, $\underline{r}_{Strict} = -.62$, $\underline{r}_{Lenient} = -.59$. Based on these results the amount of variance in the probe 2 recall scores for signs in sets A through D that could be explained by the sign training position is 38% (strict scoring) or 35% (lenient scoring).

In summary, the relationship between sign training order and recall performance on the probes was generally weak and nonsignificant. Only the relationship between probe 2 performance on sets A through D by the controls was moderately high. Since the correlation was negative, it indicates that for sets A through D, signs presented early in training to control subjects were recalled better than signs presented later.

Acquisition and Recall of Signs in Sets A Through D Versus Sets E Through H

In order to limit the length of training sessions and obtain short-term retention data on all signs aphasic and control subjects received training on one group of signs during session one, and a second group of signs during session two. Sign sets A through D were trained to subjects during one session and sign sets E through H were trained during the second session. During the training several aphasic and control subjects remarked that signs in sets E through H were more difficult for them to acquire and recall than signs in sets A through D. In order to examine this issue the acquisition and recall data from each subject group were analyzed to determine if there was a significant difference between the two groups of signs.

None of the means were found to be significantly different from one another for either the aphasic, $\underline{t}(11) = .201$, $\underline{p} = .82$, or control subjects, $\underline{t}(11) = .57$, $\underline{p} = .58$.

The number of sign parameters performed correctly on signs from sets A through D and E through H by subjects on the initial tests was examined by the Wilcoxon matched pairs test, because the data from the control subjects was determined to have a significant negative skew. The difference between the number of parameters performed correctly on the test for signs from sets A through D compared to signs from sets E through H was found to be significant for the control subjects under lenient scoring, Wilcoxon $\underline{T} = 12.00$, $\underline{p} = .03$. The difference for the controls under strict scoring, approached significance, Wilcoxon $T = 17.5$, $p = .09$. These results indicate that under lenient scoring control subjects produced more sign parameters correctly on the recall test for signs in Sets A through D compared to the number of parameters performed correctly for signs in sets E through H. This result was not found for the aphasic subjects. Also, no significant differences were found between the recall on probe 2 of signs in either of the two groups A through D and E through H.

Therefore, although both the aphasic and control subjects believed that signs in sets E through H were more difficult to acquire and recall than signs in sets A through D, only the controls performance under lenient scoring on the test indicated a significant difference in recall between signs in the two sets.

"No Response" Signs: Their Features

In the following discussion the features common to the signs that did not elicit a response on recall trials will be presented.

Shown in Table 31 are the number of trials associated with each sign where no response was produced by individual subjects. The numbers presented are for the three recall evaluations. The control

Table 31

Number of Recall Trials and Specific Signs Where No Response Was Produced by Each Subject

	Test		Probe 1		Probe 2	
Aphasic Subjects	Sign	Num. Trials	Sign	Num. Trials	Sign	Num. Trials
JS	AIRPLANE	4	COP	1	CAT	1
	CAT	2	STORE	1		
	CHILD	2	WOMAN	1		
	EGG	4				
AA					APPLE	1
					TOILET	1
					WATER	1
DJ						
RB						
MF	TOILET	4	SHOES	1	EGG	1
					FOOD	1
					SHOES	1
					TOILET	1
SS	BLANKET	4	BOOK	1		
	BOOK	4	SHOES	1		
	EGG	3	WATER	1		
			WOMAN	1		
EA	FOOD	2	TOILET	1	CLOTHES	1
	TOILET	4	WATER	1	STORE	1
			WOMAN	1		

continued

(Table 31 continued)

	Test		Probe 1		Probe 2	
Aphasic Subjects	Sign	Num. Trials	Sign	Num. Trials	Sign	Num. Trials
PB	EGG	4	EGG	1	AIRPLANE	1
	TOILET	4	FOOD	1	EGG	1
			SHOES	1	FOOD	1
			TOILET	1	SHOES	1
					TOILET	1
					WATER	1
Total		41		15		16
Control Subjects						
BB						
JB	EGG	1			AIRPLANE	1
					EGG	1
BL					EGG	1
					WATER	1
JT					CLOTHES	1
FM					CLOTHES	1
					WOMAN	1
EW						
Total		1				7

subjects did not respond on one test trial and seven probe 2 trials. The remaining descriptions of the features of "no response" signs will be discussed separately for each subject group.

Aphasics. On the tests the sign that was responsible for the highest number of "no response" trials was TOILET (12 trials), followed by EGG (11 trials). As shown in Table 31 seven out of the eight (87.5%) "no response" signs were -body contact signs, indicating that for the aphasics body contact may have influenced whether enough information was recalled about a sign to allow the subject to produce a response when requested to do so. On the probes the "no response" signs were primarily low and medium translucency signs (60% - 67%). These results indicate that body contact may have been important in eliciting a response on the test, and translucency may have been important for the probes, though neither of the two levels of production complexity were found to be differentially represented among the "no response" signs.

Controls. The controls' "no response" signs were a subset of those from the aphasics, EGG on the test, and AIRPLANE, EGG, WATER, CLOTHES, and WOMAN on probe 2. Three out of these five signs were low translucency signs, and one each was medium and high translucency. Neither of the two levels of body contact or production complexity appeared to be important variables in eliciting a recall response from the control subjects.

CHAPTER V

Discussion

Summary of Results

Acquisition and recall of signs was expected to be negatively influenced by stroke and the results generally supported that hypothesis. Aphasics required significantly more handshaping and physical guidance training trials than controls during sign acquisition, and aphasics acquired significantly fewer signs than control subjects. Recall of signs was also significantly impaired in aphasics compared to controls on the immediate posttraining tests (initial tests) and the same-day probes (probe 1). The performance of the aphasics on the one-week posttraining probe (probe 2) was not significantly impaired compared to the controls. This result indicates that although aphasics did more poorly than controls on acquisition and same-day recall of signs, when the memory demands were increased by delaying recall for one week, the performance of the controls was just as impaired as that of the aphasics.

For the three variables, production complexity, body contact, and translucency the following results were obtained:

1. Production complexity was found to significantly influence sign acquisition for the aphasics but not for the controls. However, recall of signs was not significantly influenced by production complexity. Therefore, the production complexity value of a sign determined its ease of acquisition by the aphasic subjects.

2. Body contact did not influence sign acquisition by either aphasics or controls, though recall of signs was influenced by body contact. Both the aphasic and control subjects recalled significantly more body-contact signs than non-body-contact signs on the initial tests. On both probes 1 and 2 the benefit of body contact on sign recall was only observed for the control subjects. Thus, although both the aphasics and controls used body contact to aide initial sign recall, the normal controls were more likely than the aphasics to use body contact to aide delayed sign recall.

3. Translucency was not found to influence sign acquisition or initial sign recall in either the aphasics or controls. Sign translucency did however influence recall by the aphasic subjects on probes 1 and 2. Specifically, on probe 1 significantly more medium and high translucency signs were recalled compared to low translucency signs, and on probe 2, significantly more high translucency signs were recalled compared to medium and low translucency signs. Therefore, aphasics were more likely than control subjects to use a sign's translucency feature to facilitate delayed sign recall.

Comparisons of aphasics to control subjects on the three variables indicated that the aphasics' recall performance was significantly impaired compared to the controls' on the initial tests and probe 1. On probe 2 no overall significant differences were found between the two groups. Analysis at the individual levels of the three independent variables revealed, however, that aphasics were significantly impaired compared to the controls on probe 2 body-contact signs and low translucency signs. A summary of the major results is presented in Table 32.

Table 32

Summary of Major Findings Obtained From the Present Study

	Acquisition		Recall					
			Initial Tests		Probe 1		Probe 2	
	Aph	Cont	Aph	Cont	Aph	Cont	Aph	Cont
Produc Comp	HPC > LPC	--	--	--	--	--	--	--
Body Contact	--	--	+BC > -BC	+BC > -BC	--	+BC > -BC	--	+BC > -BC
Translucency	--	--	--	--	Med > Low High	--	High > Med Low	--

Note. Aph = Aphasics; Cont = Controls; -- = No effect found.

The acquisition order for the four individual sign parameters, handshaping, hand orientation, location, movement, differed between the two subject groups. The modal order among the aphasic subjects was hand orientation > location > handshape > movement, and among the controls the order was handshape = hand orientation > location > movement. Therefore, the movement parameter was the most difficult to acquire by both subject groups. An investigation of individual aphasic subjects' results indicated that the order of acquisition was unique for six of the eight subjects. However, the movement parameter was acquired last by seven of the eight subjects.

The recall order for the four sign parameters among the aphasic subjects on the initial tests and probe 1 was location > hand orientation > movement > handshape, and the order on probe 2 was hand orientation > location > movement > handshape. The order of sign parameter recall by the control subjects was influenced by the removal of touch errors from the scoring (lenient scoring). Under strict scoring the following order was obtained on all three recall evaluations: location > hand orientation > handshape > movement. Under lenient scoring the order of parameter recall was location > hand orientation > movement > handshape. Therefore, for both subject groups the most difficult parameters to recall were movement and handshape.

In terms of the three movement error types (intrusion, unrelated, and duplication) both aphasics and controls produced these error types during recall. Of the three types of errors examined duplication errors were the most often produced by aphasics on the tests and probe 1. The hierarchical order of movement error types produced by the aphasic subjects was duplication > intrusion > unrelated, on the tests and probe 1, and on probe 2 the order was unrelated > duplication > intrusion. The order for the controls was duplication > intrusion > unrelated on the tests, and intrusion > duplication = unrelated on probes 1 and 2. Therefore, during same-day sign recall (initial tests and probe 1) aphasics and controls were likely to repeat sign productions beyond the required number of movement cycles, however, during delayed recall (probe 2) unrelated errors were the usual cause of the aphasics impaired performance while intrusion errors were the cause of the control subjects' impaired performance.

The aphasic subjects' performance on the gesture subtest that evaluated transitive movements (pretend object use) was found to be strongly related to sign recall on the initial tests and moderately related to sign recall on probe 1. Although, no strong relationship was found between recall on the test or probe 1 and expressive speech, probe 2 recall was found to be moderately related to the aphasic subjects' expressive language performance.

Receptive signing errors were produced by four aphasics (SS, RB, DJ, JS) and no controls. The compelling features of the six signs on which receptive errors were made were that all were non-body-contact signs and four of the six were high production complexity signs. Two of the receptive errors were particularly interesting because the relationships between the sign presented and the pictorial referent chosen were more linguistic than arbitrary. Examination of the errors revealed that the incorrect choice of the picture of a book as the referent for the sign PENCIL, was semantically related, and the choice of comb as the referent for TOILET was associatively related.

No significant difference was found between the acquisition and recall of signs from the two groups of sets (A through D and E through H) for the aphasic or control subjects on the initial tests and probe 1. However, under lenient scoring on probe 2 the control subjects were found to recall significantly more signs from sets A through D compared to signs from sets E through H. This result suggests that although all signs were recalled with equal difficulty by the aphasics and controls on the first day of training, signs in sets A through D were easier for the control subjects to recall compared to those in sets E through H at the one-week posttraining evaluation.

The number of trials where no response was produced during recall was higher for aphasics than controls. The primary feature of the signs on which aphasic subjects refused to respond on the test was lack of body contact, since most of these signs were non-body-contact signs. On the probes "no response" signs were primarily of low and medium translucency.

Among the control subjects no particular feature was salient among the "no response" signs.

Sign Acquisition and Recall in Aphasia

The results of this study, like the majority of others on gesture in aphasia, indicate that aphasics are impaired compared to normal controls in the acquisition and recall of symbolic gestures. This finding also supports the results from studies on new motor learning which have found that left hemisphere lesions impair the acquisition and retention of motor skills (Heilman, Schwartz, & Geschwind, 1975).

There are four theories that have been advanced to explain the observed aphasic gestural deficit: asymbolia, modality, apraxia, and cognitive. The results of the present investigation will be discussed as they relate to the asymbolia, modality, and apraxia theories.

Asymbolia Theory

Finkelnburg's asymbolia theory (Duffy & Liles, 1979) proposes that the human brain possesses one central communication and symbol system which when damaged results in impaired performance on all tasks that require manipulation of symbols. Therefore, the aphasics' impaired rate of acquisition and recall of ASL signs could be the result of damage to the central communication symbol system. However, the finding that sign translucency (degree of perceived relatedness between a sign and its meaning) was strongly related to the aphasic subjects' performances on probe 1 and probe 2 does not lend support to the asymbolia theory, particularly, since the asymbolia model suggests that symbolic movements should be less well interpreted than abstract movements.

One suggestion for why translucency did not influence sign acquisition and immediate recall in the present study is the sign training and test procedure. Subjects did not observe the signs being produced until the receptive test was administered, following the elicited recall test. On the receptive test subjects observed the sign being produced and were required to select the associated pictorial referent from among the three pictures. It is possible that when subject's were given the opportunity to observe the signs being produced in the presence of their referents, a symbolic link was formed.

In the studies where translucency or iconicity was found to influence sign or gesture acquisition (Luftig & Lloyd, 1981; Konstantareas, Oxman, & Webster, 1978) the training procedure differed from the one used in this study. In those studies, during training the signs were produced by the examiner in the presence of the pictorial referent, which suggests that only by observing the production of a sign, along with its referent, can one develop the conceptual link that is necessary to understand how a sign is related to its referent, the crucial factor in sign translucency. Since in the present study the opportunity to observe production of the signs did not occur until after training had been completed, the conceptual link developed by the aphasics was not apparent until the end of the training session (probe 1) and again at the one week posttraining probe (probe 2). The presence of a mirror during training may have helped the subjects by allowing them to develop a visual representation of the sign that could then be used to develop the sign-referent association. Under these conditions the the translucency variable's effects might have been stronger.

Modality Theory

The modality theory proposes that the gestural deficit observed in aphasia is due to to a breakdown in specific perceptual modalities. Studies conducted by Varney (1978, 1982) have found a specific relationship between deficits in pantomime recognition and impairments in reading comprehension. Based on Varney's work, in order for the modality theory to have been supported in the present study impaired gesture performance would have to be shown to have a comparable effect on its linguistic counterpart (expressive speech) (Varney, 1978). Investigation of the relationship between the observed expressive gestural deficit (acquisition and same-day recall) and expressive speech, as measured by three BDAE expressive language subtests (visual confrontation naming, word reading, and repetition of words), revealed low to moderate negative correlations between the same-day recall performances (test and probe 1) and all three expressive language subtests . These results indicate that subjects with poor BDAE expressive scores had better gestural performances than those with good oral expression.

The moderate to high positive correlations obtained between the expressive speech subtests and the probe 2 recall performance reveal that when long-term memory demands are added to ASL sign recall, aphasics perform almost as poorly on the signs as they do on expressive language tests. Therefore, deficits in expressive language may be a good predictor of how well signs will be performed over time. The probe 2 results provide moderate support for the modality theory.

In the present study, the low correlations obtained between expressive language and same day recall sign performance support Kadish's (1978) finding of a nonsignificant relationship between speech production and expressive gesture. The previous studies that have obtained results in support of the modality theory have primarily reported high correlations between reading comprehension and gesture comprehension. However, studies showing a strong relationship between expressive gesture and speech are less common. Since the results of this study also did not provide strong support for the modality model, it may be that the modality model holds more strongly for receptive than expressive gesture.

Apraxia Theory

According to Liepmann (1900/1977; Kimura, 1980) apraxia is not caused by language or symbolic deficits. Rather, he argues that praxis is an independent functional system. As delineated by Heilman (1979) this functional system extends from the parietal cortex to the frontal lobe. Dysfunction of the praxis functional system could cause slow acquisition of signs. According to Heilman's (1979) model, in order for a subject to have produced a correct sign during training, the following chain of events would have to occur. Movement is initiated by verbal commands projected to Wernicke's area. The idea of the movement is then projected to the parietal lobe where the visuokinesthetic motor engrams are located. These engrams then organize a sequence of movements associated with the sign's production and each of these movements is then sequentially programmed in the motor performance system (Rothi & Heilman, 1984) located in the motor association cortex. The motor association cortex in turn controls the production of the complete sign via the primary motor system located in the motor cortex. An impairment in precise movements would be observed following destruction of the primary motor system, and disconnection from the visuokinesthetic motor engrams would impair complex motor activity.

In the present study five of the eight aphasic subjects (JS, AA, RB, MF, SS) suffered cerebral damage that extended from the parietal to the frontal lobe. The remaining three subjects suffered either frontal lobe damage exclusively (DJ), or damage that extended from the frontal lobe to the temporal cortex (PB, EA). The anatomical evidence thus suggests that much of the hypothesized praxis system may have been damaged in these subjects. Further evidence to support this hypothesis comes from the observation that six of the eight aphasics displayed right hemiparesis, and seven of the eight exhibited between moderate to severe impairment on the Kimura Movement Copying Test. The high positive correlations obtained between the aphasics' initial tests and performance on the transitive movements (pretend object use) praxis subtest ($r = .85$), and the moderately high negative correlation observed between the production complexity feature and sign acquisition ($r = -.57$), further suggest that a praxis disorder was present in most of the aphasic subjects. The praxis disorder observed among the aphasics is believed to be responsible for why the aphasics as a group required significantly more training trials to acquire ASL signs, acquired significantly fewer signs, and recalled significantly fewer sign parameters on the test and probe 1.

The subjects whose gesture impairment was probably not parietal in nature were subjects DJ and SS. CT scan indicated that DJ's cerebral damage was confined to the frontal lobe, suggesting that her gestural deficit may have been caused by either disconnection from the motor engrams or damage to the primary motor system. Subject SS, whose performance on the BDAE indicated a Broca's aphasia, also may have suffered more anterior damage, possibly in the motor cortex or motor association cortex. Subject DJ acquired the lowest number of signs, 16, and SS only acquired 22 signs. These two subjects were also among the four who produced receptive sign errors, and performed poorly on the BDAE auditory comprehension subtests and the Token test. The especially poor performances by both of these subjects suggest that they may have been displaying a different type of apraxia than the others, possibly one that was more anteriorly based.

In summary, although there was moderate support for the modality theory from the probe 2 results, the majority of the findings of the present study suggest that an apraxia associated with the subjects' aphasia was responsible for the poor acquisition and recall of ASL signs. The low to moderate associations between recall and expressive language further indicate that Kimura's concept of a breakdown in complex sequential manual motor activity may not be the best explanation for the apraxia observed, but rather, that it is best explained by impaired motor engrams, as described by Liepmann (1900/1977) and further delineated by Heilman (1979).

Specific Apraxia Errors Exhibited During Sign Execution

Parameter Errors

The subjects' sign performances were evaluated throughout training (acquisition) and recall according to correct simultaneous execution of the four parameters associated with each sign. The order for acquisition of the four sign parameters by the aphasics and controls in the present study was very different from that observed for deaf and hearing children of deaf parents (Kantor, 1980; Wilbur & Jones, 1974) and deaf mentally retarded children learning signs in a training environment (Doherty, 1985). Specifically, these investigators found that production errors were greatest on handshape, followed by movement, and least on the location parameter. The hand orientation parameter was observed by Kantor (1980) to be acquired simultaneously with the handshape parameter. The sequence of acquisition found in the present study more closely followed that found by Crittenden (1974) for hearing college students on a receptive sign identification task following completion of an introductory sign course. Crittenden (1974) found that the largest number of confusion errors occurred on signs differing in movement followed by those differing in handshape and the least number of errors were on signs differing in location. Hand orientation was not examined. In the present study both the aphasics and controls acquired the movement parameter last. The controls acquired handshape and hand orientation simultaneously, as did Kantor's (1980) subjects. In the present study these parameters were acquired in the early stage of acquisition compared to Kantor's subjects who acquired these two parameters in the final stage of acquisition. In the present study the values for the handshape, hand orientation, and location parameters were generally very close, indicating that they were acquired at very similar points in training.

The difference in the acquisition sequence observed in the present study may be attributed to the procedure of handshaping and physical guidance used during sign training. It is possible that by molding the hand into the correct handshape and orienting the hand in the correct direction the trainer may have provided kinesthetic cues that facilitated earlier acquisition of the handshape and hand orientation parameters by both subject groups. A problem that surfaced during training which may be responsible for the slow acquisition of the movement parameter was the difficulty in guiding subjects through a movement that they had never observed. Since the subjects had not observed the sign produced they had no idea of the movement they were expected to produce and thus many errors were made while the trainer tried to get the subjects to relax and allow their limb to be put through the movement. There was stiffness and tenseness that had to be overcome, particularly in the aphasics.

According to Adams' theory of motor skill learning (1971; 1976) movements are initiated by a "memory trace" and must have direction and extent; however, once a movement has been produced its reproduction is dependent on a "perceptual trace" to guide the limbs and to judge the movement's correctness. In this experiment the stiffness and rigidity exhibited by subjects upon initial exposure to each sign's movement, may have had an unfavorable effect on the kinesthetic feedback obtained during initial production of the movement. Therefore, the kinesthetic feedback may have been insufficient to allow the development of an adequate "perceptual trace" to guide the limbs to the correct location when the movement had to be reproduced.

The hierarchical ordering in memory among the four sign parameters by the aphasics and controls in this study also closely followed Crittenden's (1974) findings. The location parameter was recalled with the fewest number of errors, followed by hand orientation, and the largest number of errors were produced on the handshape and movement parameters. The values for the handshape and movement parameters were generally not significantly different from each other. One can only speculate as to why handshape and movement were the most difficult to recall. It is possible that the poor recall of these parameters may reveal the greater sensitivity of the aphasics to the motor demands of executing handshape and movement.

The observed salience of the location parameter during recall may be explained by Doherty's (1985) suggestion that contact may serve to help sign learners register the location of signs. As the results indicate, body contact did not influence the rate of sign acquisition, though the body contact feature influenced sign recall on the initial tests for both aphasics and controls and was also a factor in the control subjects' performance on probes 1 and 2. Additional support for the importance of body contact comes from the finding that there was a trend in the aphasics' probe data for more body-contact signs to be recalled than non-body-contact signs.

Movement Errors

The largest proportion of movement errors produced by aphasics on the test and probe 1 were duplication errors. However, on probe 2, unrelated errors became responsible for the largest proportion of movement errors. The controls produced more duplication errors on the test but on the probes the largest proportion of their errors were attributed to intrusions. The majority of these dúplication errors were observed to be repetitions of the appropriate movement. The finding for both subject groups that duplication errors were dominant on the test, and dominant for the aphasics on probe 1, suggests that the subjects may have added extra movements to help them remember the signs during early exposure. This result supports Doherty's (1985) suggestion that repetition during the initial stages of sign acquisition may provide additional sensory information that could facilitate sign learning.

The finding that on the probe administered one week following training (probe 2) control subjects produced proportionally more intrusion errors while aphasics produced proportionally more unrelated errors, indicates that when the memory demands were highest (probe 2) aphasics were more likely to produce a gesture with no relationship to the signs that had been trained and controls were more likely to produce a gesture that contained some elements from the group of signs that they had learned. Observation of the aphasic subjects' performances on probe 2 revealed that many of the unrelated errors they produced were pantomimes associated with the picture presented to elicit the sign. For example, several subjects pantomimed pulling a string when the toilet sign was being elicited or dialing a telephone when TELEPHONE was being elicited. Thus, although the gestures produced were unrelated in terms of movement to the signs that they had learned, they were not unrelated to the referent being elicited by the picture.

In terms of individual aphasic subjects' production of movement errors, it was interesting to note that the performances of two severe aphasics EA and SS were very similar. On probe 1 and probe 2 both of these subjects produced a large proportion of intrusion errors. The movement most responsible for

SS's intrusion errors was the "down and away" movement associated with the production of the sign CLOTHES.

Since intrusion errors were defined as a response that includes all or part of another sign, some intrusion errors may not have been intrusions but rather paraphasias. Goodglass and Kaplan (1972) define a paraphasia as "the production of unintended syllables, words or phrases during the effort to speak" (p. 8). During elicited and receptive signing both aphasic and control subjects produced errors that could be labeled "gestural paraphasias". The type of gestural paraphasia most often produced was a complete reproduction of another sign from the training set when a specific target sign was being elicited. This type of error was similar to a verbal paraphasia produced when speaking, thus, a type of gestural analog of a verbal paraphasia.

The clothes sign was responsible for a substantial number of these gestural paraphasic analogs. The error observed most often was a complete reproduction of CLOTHES when the picture to elicit STORE was presented. Both aphasics and controls produced this error, however aphasics produced a greater number of them compared to the controls. In addition to the possibility that this error was a gestural paraphasia it may have been caused by a similarity in the pictures depicting clothes and a store. The finding underscores the need for caution regarding the selection of sign training stimuli.

Additional gestural paraphasic analogs included the production of CLOTHES when CAT was being elicited, CHILD when BABY was being elicited, CHILD when MAN was being elicited, and SHOE when BLANKET was being elicited. Of the six aphasics (AA, SS, EA, MF, JS, DJ) who produced errors that could be interpreted as gestural analogs of verbal paraphasias, three of the aphasics (AA, EA, MF) were also found to produce verbal paraphasias on the Boston Diagnostic Aphasia Examination administered prior to training. This result suggests that there may be a relationship between the production of verbal paraphasias while speaking and gestural analogs of verbal paraphasias while signing.

Additional Issues

Sign Training Order

The recall performances of the aphasic subjects were shown to have a weak relationship to a sign's position in training. The relationships observed for the controls were in general very weak as well, except for a moderate negative relationship observed for recall of signs in sets A through D on probe 2. For control subjects, signs in sets A through D presented early in training were recalled better than signs presented later.

<u>Perception of Sign Set Difficulty</u>

Overall subjects performed about the same on signs from both groups of sets. Although several subjects remarked that signs in sets E through H appeared more difficult to acquire and recall than those in sets A through D there was only a slight indication that this may have been true. It is difficult to understand why subjects felt one group of signs were more difficult than the other since there were no significant differences between the two sets on the variables of translucency, production complexity, or body contact. However, there was a trend for signs in sets E through H to be less translucent than those in sets A through D and this may account for the perception that these signs were less difficult. This finding suggests that compared to production complexity and body contact, translucency may have a stronger impact on the *perceived* acquisition and recall difficulty of a sign.

"No Response" Signs

Signs with no body-contact and low and medium translucency were the ones most likely not to elicit a response from the aphasic subjects. This result suggests that in order to insure that subjects, particularly aphasics, recall signs following training the signs should be highly translucent and incorporate body contact in their production.

Practical Implications of the Results

These findings support an apraxia based brain model that stresses the importance of visuokinesthetic motor engrams in the acquisition and recall of skilled movements. It has also been shown that apraxic aphasics are capable of acquiring and recalling communicative gestures, although acquisition and recall are impaired compared to normal controls.

The results of the present investigation also support the development of an empirical definition of movement production complexity that includes an examination of as many aspects of the movement as is practical. As shown in this study, evaluations of movement provide important data which can help the clinician to more completely describe praxis errors observed. The high correlations obtained between pretend object use (transitive) movements and recall imply that pretesting of such movements may help to determine which aphasic subjects may benefit best from ASL sign training.

In terms of the three sign features examined in this study, the results suggest that among apraxic aphasics production complexity may be more important for sign acquisition, and translucency may be more important for sign recall. Body contact, although an apparently important feature in the recall of signs by normal controls, may not be as important for the long-term recall of signs by apraxic aphasics.

The implications of these results for other types of aphasics are intriguing. For example, these results imply that production complexity may not be an important feature in sign acquisition among nonapraxic aphasics. Also, aphasics who exhibit conceptual deficits (e.g., Wernicke's and global) may not be able to use translucency to assist in sign recall.

Suggestions for Future Research

The finding that aphasics and controls recalled similar numbers of sign parameters on the probe administered one week following training suggests that although both subject groups forgot information, the aphasics recall signs almost as well as controls. On probe 2 translucency was found to be more important for aphasics, while body contact was more important for controls. Focusing on signs of high translucency may facilitate long term recall of signs in the aphasic patient. Future studies using larger subject groups are needed to further examine the features of signs that can facilitate their acquisition and recall.

Also needed are studies to chronicle the long term use of communicative gestures once training has been completed, and explore practical methods for encouraging use of these gestures among subjects and their families.

In summary, the results of the present study are consistent with Liepmann's apraxia theory which conceptualizes aphasia and apraxia as separate disorders that are sometimes associated because of the contiguity of the underlying cerebral structures that mediate language and praxis. They do not seem to support the theory that aphasia and apraxia are both manifestations of an underlying central symbolic deficit, though the use of such a small sample of subjects and the many questions left unanswered, make it difficult to state this categorically. The purpose of this study was to explore some of the features that influence sign acquisition and recall among aphasics. The results indicate that future work needs to focus on techniques that will facilitate gesture recall and use among aphasics.

Appendix A

Tactile Perception Evaluation

Instructions: Have subject close eyes. The examiner touches or strokes stimulus area. Subject is asked, "what did you feel?".

Stimulus Area Response

1. Left cheek

---

2. Left trunk (stomach)

---

3. Left side of face

---

4. Left mid face (nose area)

---

5. Left top of head

---

6. Left chin

---

7. Left forehead

---

8. Left hand

---

9. Left shoulder

---

10. Left chest

---

11. Midline chin

---

continued

Appendix A (continued)

12. Midline chest

---

13. Midline trunk

---

14. Right shoulder

---

15. Left lip

---

16. Midline lip

---

17. Right trunk

---

18. Right side of face

---

19. Right hand

---

20. Top of head (midline)

Appendix B

Apraxia Battery

A. Gesture Comprehension

1. Movement Identification Test.

   Instructions: Have patient identify movement produced by the examiner from a series of pictures depicting various arm and hand movements.

   Scoring: Items scored 1 point for each correctly identified movement.

   Maximum Score: 5 points.

2. Pantomime Recognition Test (Varney & Benton, 1978).

   Available from: Benton Laboratory of Neuropsychology, University of Iowa Hospitals, Iowa City, Iowa.

   Maximum Score: 30 points.

B. Gesture Production

1. Nonrepresentational Movements

a. Kimura Hand Posture Copying Test (Kimura, 1982).

Instructions: Present hand posture. Have patient produce hand posture from memory. If the patient fails on this trial he is given a second trial in which to copy directly from the examiner's hand which serves as a model throughout the trial.

Scoring: Each posture is scored 2, 1, or 0 depending on whether it was correctly copied on first or second trial, or not at all.

Maximum Score: 10 points.

b. Additional Hand Postures for Copying.

Instructions and Scoring: Same as for Kimura Hand Posture Copying Test (Kimura, 1982).

Maximum Score: 16 points.

(1) X-hook hand

(2) C-curved hand

(3) O-tapered hand

(4) H-index and second finger

(5) A-fist

(6) F-"3 ring"

(7) Y-"horns" hand

(8) W-3 finger hand

c. Kimura Movement Copying Test (Kimura, 1982).

Instructions: Face the patient. Demonstrate a movement with one hand and arm. Have patient copy movement as soon as you complete it. Patient is given a second trial if all components ate not performed correctly on first trial.

Scoring: 2 = component performed correctly on first trial; 1 = component performed correctly on second trial; 0 = component not performed correctly on either trial.

Maximum Score: 24 points.

d. Additional Movements for Copying.

Instructions and Scoring: Same as for Kimura Movement Copying Test (Kimura, 1982).

(1) Rotate/twist wrist.

(2) Repeat movement - open and close fist twice.

(3) Wiggle fisted hand at wrist - back and forth movement.

(4) Circular movement with fisted hand.

Maximum Score: 8 points.

2. Representational Movements

a. Buccofacial.

Instructions: Movements are to be performed by the patient to command first. If failed to command movements should then be done to imitation. Where applicable movements failed to imitation should be done with the real object.

Scoring: Each correctly performed movement receives 2 points if done to command, 1 point if done by imitation, and .5 points if done with the real object.

Maximum Score: 6 points.

(1) cough

(2) sniff flower

(3) kiss

b. Intransitive Limb.

Instructions: Movements are to be performed by the patient to command first. If failed to command movements should then be done to imitation. Where applicable movements failed to imitation should be done with the real object.

Scoring: Each correctly performed movement receives 2 points if done to command, 1 point if done by imitation, and .5 points if done with the real object.

Maximum Score: 12 points.

away from body

(1) wave good-bye

(2) beckon "come here"

(3) signal "stop"

on body

(4) salute

(5) finger on lip for "shsh"

(6) scratch head

c. Transitive limb

Instructions: Movements are to be performed by the patient to command first. If failed to command movements should then be done to imitation. Where applicable movements failed to imitation should be done with the real object. If body-part as object (BPO) errors are observed performance should be corrected as indicated below.

Scoring: Each correctly performed movement receives 2 points if done to command, 1 point if done by imitation, and .5 point if done with the real object.

Maximum Score: 12 points.

away from body

(1) hammer (correction - "Do not use your hand as a hammer. Make believe you are really holding a hammer".)

(2) saw board (correction - "Do not use your hand (arm) as a saw. Make believe you are really holding a saw".)

(3) use screwdriver (correction - "Do not use your finger as a screwdriver. Make believe you are really using a screwdriver".)

on body

(4) brush teeth (correction - "Do not use your finger as a toothbrush. Make believe you are really using a toothbrush".)

(5) shave (correction - "Do not use your finger as a razor. Make believe you are really using a razor".)

(6) comb hair (correction - "Do not use your fingers as a comb. Make believe you are really using a comb".)

d. Whole-body Movements.

Instructions: Movements are to be performed by the patient to command first. If failed to command movements should then be done to imitation. Where applicable movements failed to imitation should be done with the real object. If body-part as object (BPO) errors are observed performance should be corrected as indicated below.

Scoring: Each correctly performed movement receives 2 points if done to command, 1 point if done by imitation, and .5 point if done with the real object.

Maximum Score: 12 points.

(1) Stand, sit, turn around, walk backwards.

(2) Stand like a boxer.

(3) Stand like a batter.

(4) How does a soldier march in place?

(5) How do you shovel snow?

3. <u>Test of Kinesthetic Memory (Nonvisual)</u>.

Instructions: Have patient close eyes. Mold patient's hand into handshape. Have patient produce hand posture from memory. If subject cannot remember handshape remold hand. Eyes should remain closed throughout test.

Scoring: Each posture is scored 2, 1, or 0 depending on whether it was correctly copied on first or second trial, or not at all.

Maximum Score: 10 points.

(1) 5-spread hand

(2) T-thumb cross

(3) B-flat hand

(4) L-angle hand

(5) X-hook hand

4. <u>Test of Emotional Portrayal</u>

Instructions: Ask patient to pretend the specified emotion.

Scoring: Items are scored 1 point for each accurately portrayed emotion.

Maximum Score: 5 points.

Show me a ________ look.

(1) sad

(2) confused

(3) happy

(4) angry

(5) afraid

C. <u>Test of Kinesthetic-Visual Matching</u>

Instructions: Mold patient's hand into handposture. From an array of three pictures have patient choose the picture matching the hand posture.

Scoring: Each correctly matched posture receives 1 point.

Maximum Score: 5 points.

(P) A D L: D

(1) H O Q: H

(2) R U E: E

(3)	T	Y	N:	N
(4)	G	F	Q:	F
(5)	A	S	M:	A

D. Test of Visual Discrimination

Instructions: Have patient judge whether two handshapes are the same or not the same.

Scoring: Items are scored 1 point if judged within 5 seconds and .5 point if discriminated correctly after hesitation.

Maximum Score: 5 points

(P)	Flat hand: "5"	Fist: "A"
(1)	Thumb cross: "E"	Curved hand: tapered "O"
(2)	Index finger: "X"	Index finger: "X"
(3)	Fist: "Y"	Fist: "A"
(4)	Thumb touch: "W"	Thumb touch: "W"
(5)	Curved hand: "C"	Curved hand: "O"

Appendix C

Desire To Communicate

1. Does patient attempt to communicate ?

2. Does patient have yes and no response?

   Describe yes response:

   Describe no response:

3. Is patient able to make choices?

4. What is the actual present means of communication?

   (check all that apply)

   ____ a. well articulated vocalizations

   ____ b. limited speech vocalizations

   ____ c. gestures

   ____ d. facial expressions

   ____ e. other

5. Does patient exhibit frustration when his/her idea is not understood?

   Rate frustration: High Medium Low

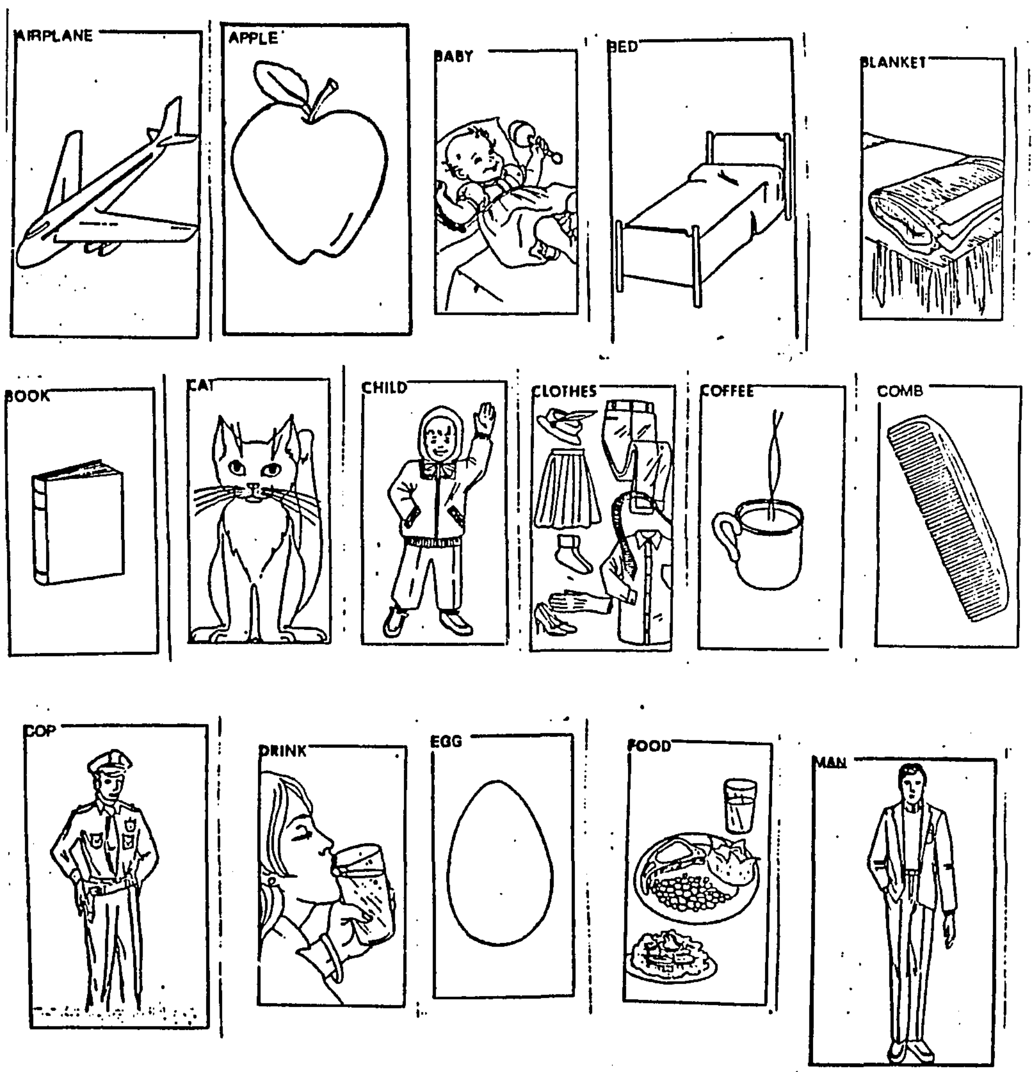
6. Is patient's present means of communication commensurate with his/her communication needs?

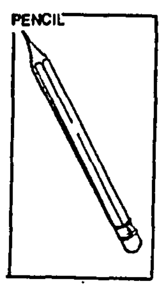
7. Are familiar persons the only ones who understand patient's speech?

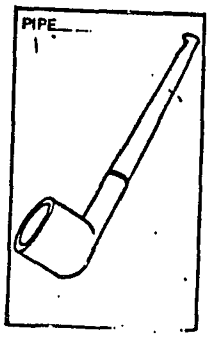
8. To what extent is an alternate mode of communication necessary as a supplement or complement to speech?

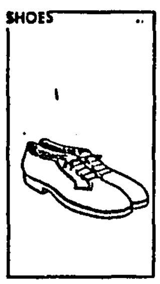
Appendix D

Pictorial Referents of Sign Stimuli

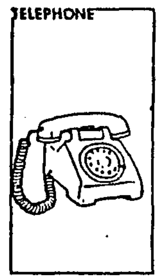

AIRPLANE
APPLE
BABY
BED
BLANKET
BOOK
CAT
CHILD
CLOTHES
COFFEE
COMB
COP
DRINK
EGG
FOOD
MAN

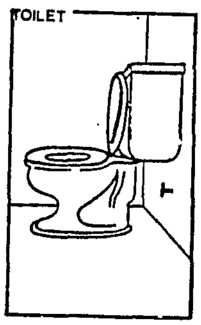

PENCIL

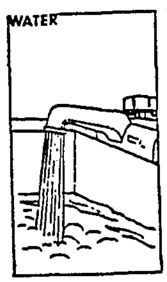

PIPE


SHOES


STORE
FASHIONS


TELEPHONE


TOILET


WATER


WOMAN

Appendix E

Determining the Translucency of Unimanual Versions of Bimanual Signs

A particular group of language impaired individuals that have been shown to benefit from ASL training are aphasics with motor impairment. These are aphasic individuals who have suffered left frontal lobe brain damage resulting in paresis on the right side. The hemiparesis usually leaves only one hand available for manual activities such as signing. Prior to teaching such aphasic individuals one-handed (unimanual) versions of two-handed (bimanual) ASL signs a study was done to examine the effect of unimanual productions of bimanual signs on perceived translucency.

The purpose of the present study was to answer the following question: When a limited set of bimanual ASL signs are produced unimanually, what is the effect on perceived translucency?

The goals of the present study were:

1. To obtain mean translucency ratings for unimanual productions of 18 bimanual ASL signs.

2. To determine the degree of relationship between translucency ratings of unimanual and bimanual productions of 18 ASL signs.

3. To determine the degree of relationship between translucency ratings of unimanual and bimanual productions of 9 signs to be used with aphasics in an ASL training study.

Method

Subjects. Thirty subjects with no prior knowledge of ASL participated in the study. These subjects ranged in age from 17 to 45 with a mean age of 24.8 years. Undergraduate and graduate students and college professors comprised the subject group. All subjects had essentially normal hearing and vision.

Materials. The 18 noun signs that were rated were taken from Fristoe and Lloyd's (1980) suggested core lexicon of signs and Fristoe and Lloyd's (1979) compilation of 850 words which appeared in several sign manuals. The mean translucency ratings for bimanual signs were obtained from the Luftig, Lloyd and Page (1982) and Luftig, Page, and Lloyd's (1983) translucency ratings.

A videocassette tape recording containing the randomized list of signs was used for the presentation. The videotape was produced in a format identical to that used by Luftig, Lloyd and Page (1982):

> Each sign was presented twice in succession. During both sign productions a graphic representation of the sign's meaning was visible on the lower portion of the video screen. During the first sign presentation, thé sign's gloss was spoken as the signer produced the sign. Both the signer and the speaker were female. A 78-second blank screen interval separated the offset of the second production of a sign from the onset of the next sign produced. During the blank interval, the sign number as it appeared on the videotape sequence and on the subject's rating sheet was announced. Signs were shown on a 19-inch color television monitor. (p. 310)

Procedure. The procedure used in the present experiment was identical to that used by Luftig, Lloyd and Page (1982) to obtain translucency ratings on 380 ASL signs.

Upon entering the viewing room the subjects were given instructions defining translucency and describing their rating task, as follows:

> In this study you will be shown manual signs and asked how closely the form of each sign seems to be related to its meaning. You will hear a number which corresponds to a number on your answer sheet. Immediately after hearing the number you will see on the screen a person making a manual sign. She will make the sign two times. You will also be given the meaning of each sign.
>
> Your task is to rate each sign according to how closely you think the sign and its meaning are related. Circle 1 to show that you can see no relationship between a sign and its meaning. Circle 7 to show that you can see a very strong relationship. Please make a rating for each item. You should circle one and ONLY ONE number for each sign. You may use any number as many times as you wish.
>
> Since there will not be a great deal of time between signs, you should not spend too much time on any one rating. Also, do not go back to revise

ratings of words encountered earlier. Prior to beginning the task, five practice trials will be provided. These are numbers P1 - P5 on your answer sheet (see Figure E-1). Do you have any questions?

Upon receiving instructions, all subjects were given a rating sheet which contained the number of the sign as it appeared in the list, the written word corresponding to the sign, and the numerals "1" through "7". Subjects viewed both productions of the sign and the graphic gloss of the sign on the television screen and heard the meaning of the sign via the audio track of the videotape before making a translucency judgement. Judgements were made during the 7-second interval between the offset of a sign production and the onset of the next sign production. Five seconds into the 7-second blank interval, a female voice announced the sequential number of the next sign. This served to cue the subjects to the next sign. (p. 311-312)

Production of Signs. The signs were produced by a hearing, non-native signer. A second individual,

Figure E-1. Answer sheet for study of unimanual versions of bimanual signs.

Name__________________________ Date_________________

Age_________

Relationship:		None		Moderate				Strong
P1	TOILET	1	2	3	4	5	6	7
P2	WATER	1	2	3	4	5	6	7
P3	MAN	1	2	3	4	5	6	7
P4	COP	1	2	3	4	5	6	7
P5	TELEPHONE	1	2	3	4	5	6	7

End Practice Trials

1.	COAT	1	2	3	4	5	6	7
2.	BOOK	1	2	3	4	5	6	7
3.	SHOES	1	2	3	4	5	6	7
4.	BABY	1	2	3	4	5	6	7
5.	WINDOW	1	2	3	4	5	6	7
6.	STORE	1	2	3	4	5	6	7
7.	CLOTHES	1	2	3	4	5	6	7
8.	DOOR	1	2	3	4	5	6	7
9.	COFFEE	1	2	3	4	5	6	7
10.	EGG	1	2	3	4	5	6	7
11.	COOKIE	1	2	3	4	5	6	7
12.	BLANKET	1	2	3	4	5	6	7

continued

Figure E-1 (continued)

13. TABLE	1	2	3	4	5	6	7
14. BICYCLE	1	2	3	4	5	6	7
15. CHURCH	1	2	3	4	5	6	7
16. GLASSES	1	2	3	4	5	6	7
17. KEY	1	2	3	4	5	6	7
18. PENCIL	1	2	3	4	5	6	7

fluent in ASL, checked the accuracy and conventionality of the videotaped sign productions. Each of the 18 signs was also documented against two sources. The two sources in the order of their use were A Dictionary of American Sign Language (Stokoe, Casterline & Croneberg, 1976) and A Basic Course in American Sign Language (Humphries, Padden & O'Rourke, 1980).

Results

A Pearson product-moment correlation revealed a strong relationship (r = .82) between mean translucency ratings of unimanual and bimanual productions of the 18 ASL signs listed in Table E-1.

A Pearson product-moment correlation was computed to determine the degree of relationship between translucency ratings of unimanual and bimanual productions of nine signs to be used with aphasic subjects in an ASL training study. The correlation coefficient r = .61, was not significant. The nonsignificant correlation suggested a weak relationship between the unimanual and bimanual productions of the nine signs.

To identify which means were contributing to the low correlation coefficient a scatter plot of the nine

Table E-1

Means and Standard Deviations of Translucency Ratings for Unimanual and Bimanual Productions of 16 Signs

	Unimanual Translucency		Bimanual Translucency	
Sign	*M*	*SD*	*M*	*SD*
BABY	6.10	1.30	6.88	.32
BICYCLE	4.73	1.37	5.54	1.01[a]
BLANKET	3.53	1.65	4.00	1.21[a]
BOOK	3.83	1.75	5.83	1.18[a]
CHURCH	1.63	1.14	2.71	1.10
CLOTHES	3.33	1.76	4.08	1.48
COAT	3.93	1.63	5.63	1.35[a]
COFFEE	3.30	1.57	3.34	1.53
DOOR	5.20	1.28	5.60	1.26
EGG	1.40	.80	4.29	1.84[a]
KEY	5.97	1.05	5.94	1.14[a]
PENCIL	5.87	1.36	5.82	1.29
SHOES	1.70	.82	1.97	1.15
STORE	1.67	1.42	1.77	1.00
TABLE	4.67	1.66	4.28	1.42
WINDOW	4.47	1.57	3.80	1.64

Note. [a]Standard deviations obtained from L. Lloyd (personal communication, March 17, 1986).

means was examined to identify which means lay furthest from the best-fit straight line. Figure E-2 shows the mean values for BABY, BOOK, and EGG to be the most outlying points. T-test results on the nine means further support the observation. The difference between unimanual and bimanual translucency means for the signs BABY, BOOK, and EGG was found to be significant at the .01 level (see Table E-2). The mean bimanual translucency ratings for the three signs ranged from highly translucent (BABY = 6.88, BOOK = 5.83) to moderately translucent (EGG = 4.29). The reduction in translucency ratings between the bimanual and unimanual data was .78 points for BABY, 2.00 points for BOOK, and 2.89 points for EGG.

Discussion

The results obtained from this experiment show that for the set of 18 signs evaluated unimanual productions of bimanual signs did not result in a severe loss of information regarding the perceived translucency of the sign. The relationship between the unimanual and bimanual translucency ratings was strong and significant.

Figure E-2. Scatter plot of relationship between bimanual and unimanual mean translucency values for nine ASL signs.

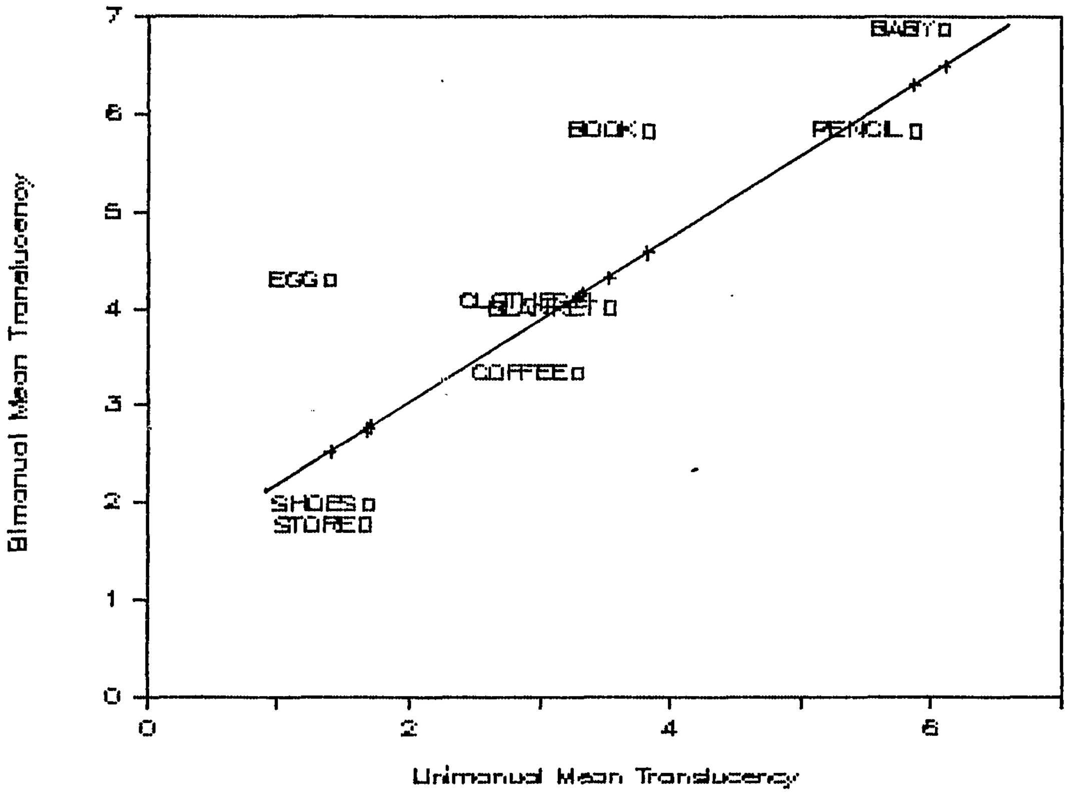

Bimanual Mean Translucency
0
1
2
3
4
5
6
7
Unimanual Mean Translucency
0
2
4
6
BABY
BOOK
PENCIL
EGG
COFFEE
SHOES
STORE

Table E-2

Means and Standard Deviations and Standard Mean Errors of Translucency Ratings for Unimanual and Bimanual Productions of Nine Signs for ASL Study

	Unimanual Translucency		Bimanual Translucency		
Sign	M	SD	M	SD	T-Ratio Value
BABY	6.10	1.30	6.88	.32	3.44*
BLANKET	3.53	1.65	4.00	1.21	1.32
BOOK	3.83	1.75	5.83	1.18	5.47*
CLOTHES	3.33	1.76	4.08	1.48	1.87
COFFEE	3.30	1.57	3.34	1.53	.10
EGG	1.40	.80	4.29	1.84	7.98*
PENCIL	5.87	1.36	5.82	1.29	-.15
SHOES	1.70	.82	1.97	1.15	1.07
STORE	1.67	1.42	1.77	1.00	.33

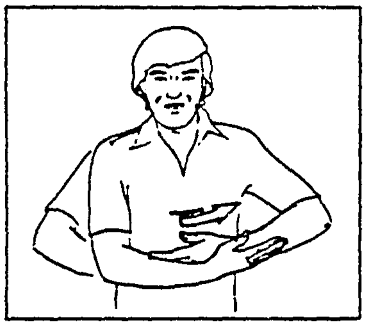
Note. * = significant at $p < .01$.

A separate analysis done on a subset of nine signs to be used in another study found a weak relationship between the unimanual and bimanual ratings. Thus, for the subset of signs perceived translucency was found to be significantly reduced between the bimanual and unimanual ratings.

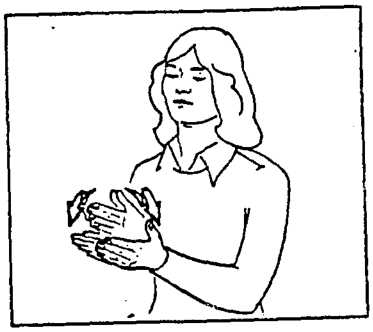
Illustrated in Figure E-3 are the bimanual productions of each of the three signs BABY, BOOK, and EGG. A possible reason for the significant loss of information between the two translucency ratings may be found from a comparison of the bimanual and unimanual productions of the three signs. The bimanual production of each of the signs incorporates an action associated with sign's referent. For example, the sign BOOK is made by placing the hands in a manner that simulates opening and closing a book. The removal of one hand in the sign production results in a degrading of the sign to such an extent that the essence of the relationship between the sign and its meaning is impaired.

Examination of each of the other two signs shows a similar need for the two hands to work together to adequately convey the essence of the sign's meaning.

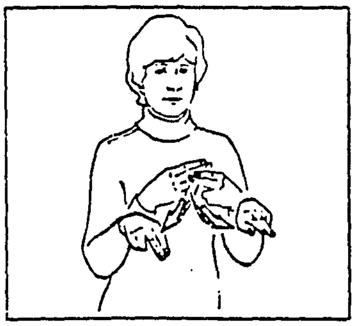
Figure E-3. Illustrated bimanual productions of three ASL signs.



BABY



BOOK



EGG

In general it appears that at least for the signs examined in this study, unimanual productions of bimanual signs do not result in a significant loss of perceived translucency unless the bimanual production of the sign incorporates essential features of the referent which are lost when the sign is produced unimanually.

Appendix F

Production Complexity Descriptions and

Values for the Twenty-four Sign Stimuli

Sign	Location	V	Handshape	V	Movement	V	Mov Pattern	V	Hand Po
AIRPLANE	neutral	1	Y-"horns"	15.25	pronating rotation/ away	4.00	parallel	5	kinetic
APPLE	cheek	2	X-hook	11.90	twisting	12.00	parallel	5	kinetic
BABY*	trunk	1	B-flat	11.90	side to side	10.25	across midline	9.5	kinetic
BED	side-face	2	B-flat	11.90	hold	0	parallel	5	static
BLANKET*	trunk	1	B-flat	11.90	upward/toward	3.13	parallel	5	kinetic
BOOK*	neutral	1	B-flat	11.90	supinating rotation	9.50	midline	5	kinetic
CAT	mid-face	2	F-"three ring"	12.50	leftward	5.00	parallel	5	kinetic
CHILD	neutral	1	B-flat	11.90	pronating rotation	7.00	parallel	5	kinetic
CLOTHES*	trunk	1	5-spread	12.25	leftward/downward	10.25	parallel	5	kinetic
COFFEE*	neutral	1	A-fist	9.00	circular	12.00	midline	5	kinetic
COMB	whole head	3	C-curved	12.10	downward	7.00	parallel	5	kinetic
COP	trunk	1	C-curved	12.10	contact	0	across midline	9.5	static

Appendix F

n Complexity Descriptions and

r the Twenty-four Sign Stimuli

	V	Mov Pattern	V	Hand Position	V	Orientation	V	Total Prod Complexity Value
tation/	4.00	parallel	5	kinetic	1	|>	11.00	37.25
	12.00	parallel	5	kinetic	1	⊽	5.00	36.90
	10.25	across midline	9.5	kinetic	1	△	12.00	45.65
	0	parallel	5	static	0	|<	8.50	27.40
d	3.13	parallel	5	kinetic	1	|<	8.50	30.53
otation	9.50	midline	5	kinetic	1	△	12.00	40.40
	5.00	parallel	5	kinetic	1	◧	6.00	31.50
tation	7.00	parallel	5	kinetic	1	⊽	5.00	30.90
ward	10.25	parallel	5	kinetic	1	|<	8.50	38.00
	12.00	midline	5	kinetic	1	◧	6.00	34.00
	7.00	parallel	5	kinetic	1	◧	6.00	34.10
	0	across midline	9.5	static	0	◧	6.00	28.60

continued

Appendix F (continued)

Sign	Location	V	Handshape	V	Movement	V	Mov Pattern	V	Hand Pos
DRINK	chin	2	C-curved	12.10	pronating rotation	2.50	midline	5	kinetic
EGG*	neutral	1	H-index & 2nd finger, side by side extended	16.80	pronating rotation	4.00	midline	5	kinetic
FOOD	chin	2	O-tapered	12.10	toward	2.50	midline	5	kinetic
MAN	forehead	2	5-spread > O-tapered	12.25	closing/away	8.50	midline	5	kinetic
PENCIL*	neutral	1	X-hook	11.90	leftward/nodding or bending	10.75	midline	5	kinetic
PIPE	chin	2	Y-"horns"	15.25	away	4.00	midline	5	kinetic
SHOES*	neutral	1	A-fist	9.00	pronating rotation	6.00	parallel rightward	5	kinetic
STORE*	neutral	1	O-tapered	12.1	downward/bending/ away	13.25	parallel	5	kinetic
TELEPHONE	cheek	2	Y-"horns"	15.25	toward/hold	0	parallel	5	static
TOILET	neutral	1	T-thumb cross	14.90	to-&-fro	3.00	parallel	5	kinetic
WATER	chin	2	W-3-finger	11.90	contact	4.00	midline	5	kinetic
WOMAN	chin > trunk	2	5-spread	12.25	downward	7.00	midline	5	kinetic

Note. V = Value. * = bimanual signs produced unimanually.

	V	Mov Pattern	V	Hand Position	V	Orientation	V	Total Prod Complexity Value
ation	2.50	midline	5	kinetic	1	[symbol]	6.00	28.60
ation	4.00	midline	5	kinetic	1	⊽	5.00	32.80
	2.50	midline	5	kinetic	1	|<	8.50	31.10
	8.50	midline	5	kinetic	1	⊽	5.00	33.75
ing or	10.75	midline	5	kinetic	1	|>	11.00	40.40
	4.00	midline	5	kinetic	1	[symbol]	6.00	33.25
ation	6.00	parallel rightward	5	kinetic	1	⊽	5.00	27.00
ing/	13.25	parallel	5	kinetic	1	⊽	5.00	37.35
	0	parallel	5	static	0	|<	8.50	30.75
	3.00	parallel	5	kinetic	1	K	11.00	35.90
	4.00	midline	5	kinetic	1	[symbol]	6.00	29.90
	7.00	midline	5	kinetic	1	[symbol]	6.00	33.25

QUEENS COLLEGE

of THE CITY UNIVERSITY OF NEW YORK

FLUSHING, NEW YORK 11367

DEPARTMENT OF PSYCHOLOGY

Appendix G

Informed Consent

Subject's Name: ________________ **Date:** ______

Project Director: Roxanne Hughes-Wheatland

Project Title: Symbolic Communication and Aphasia

Description and Explanation of Procedure: The symbolic communication skills of people with and without aphasia will be examined using words, letters, and pictures as stimuli.

Risks and Discomforts: No drugs or painful procedures. No potential risks to the subjects. The subjects are free to leave the experimental environment at any time -- there are no restraints.

Potential Benefits: Individual subjects are likely to learn techniques that may improve their communication skills during the course of their participation.

Alternatives: (Not applicable; these behavioral studies do not involve treatments of therapy.)

Consent: I have fully explained to ____________
Subject
the nature and purpose of the above-described procedure and the risks that are involved in its performance. I have answered and will answer all questions to the best of my ability.

____
Project Director's Signature

Appendix G (continued)

I have been fully informed of the above-described procedure with its possible benefits and risks. I give permission for my participation in this study. I know Roxanne Hughes-Wheatland will be available to answer any questions I may have. I know that in the event that she is not available her advisor Dr. James Tweedy can be contacted at_______________. I understand that I am free to withdraw this consent and discontinue participation in this project at any time. I have received a copy of this form.

____
Signature of Subject

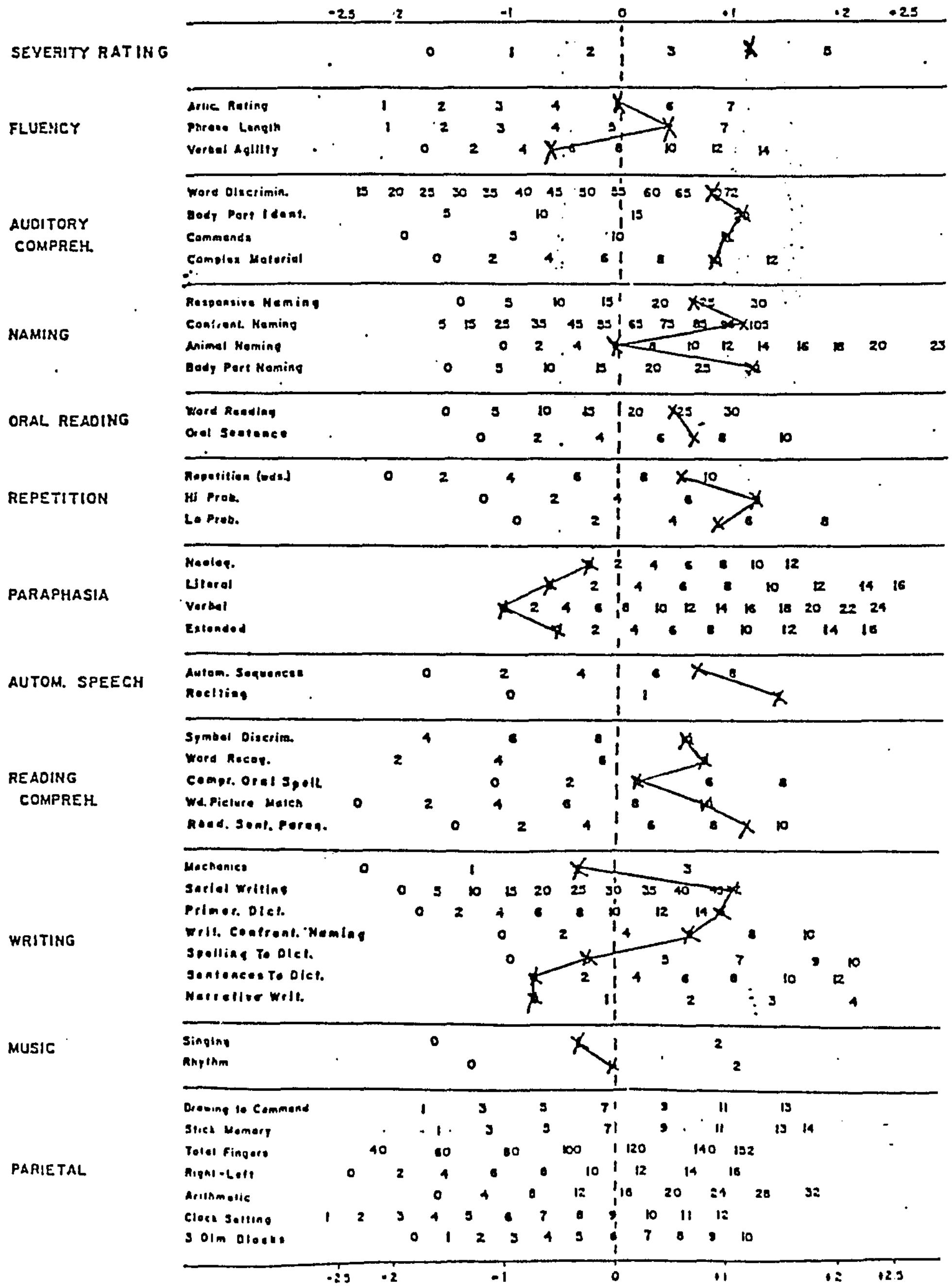
Appendix H

Language and Praxis Profiles for the Eight Aphasic Subjects

Z-SCORE PROFILE OF APHASIA SUBSCORES

NAME: JS

DATE OF EXAM:



Name: JS

Praxis Profile

Total Score = 135 = 84%

Maximum Score = 160

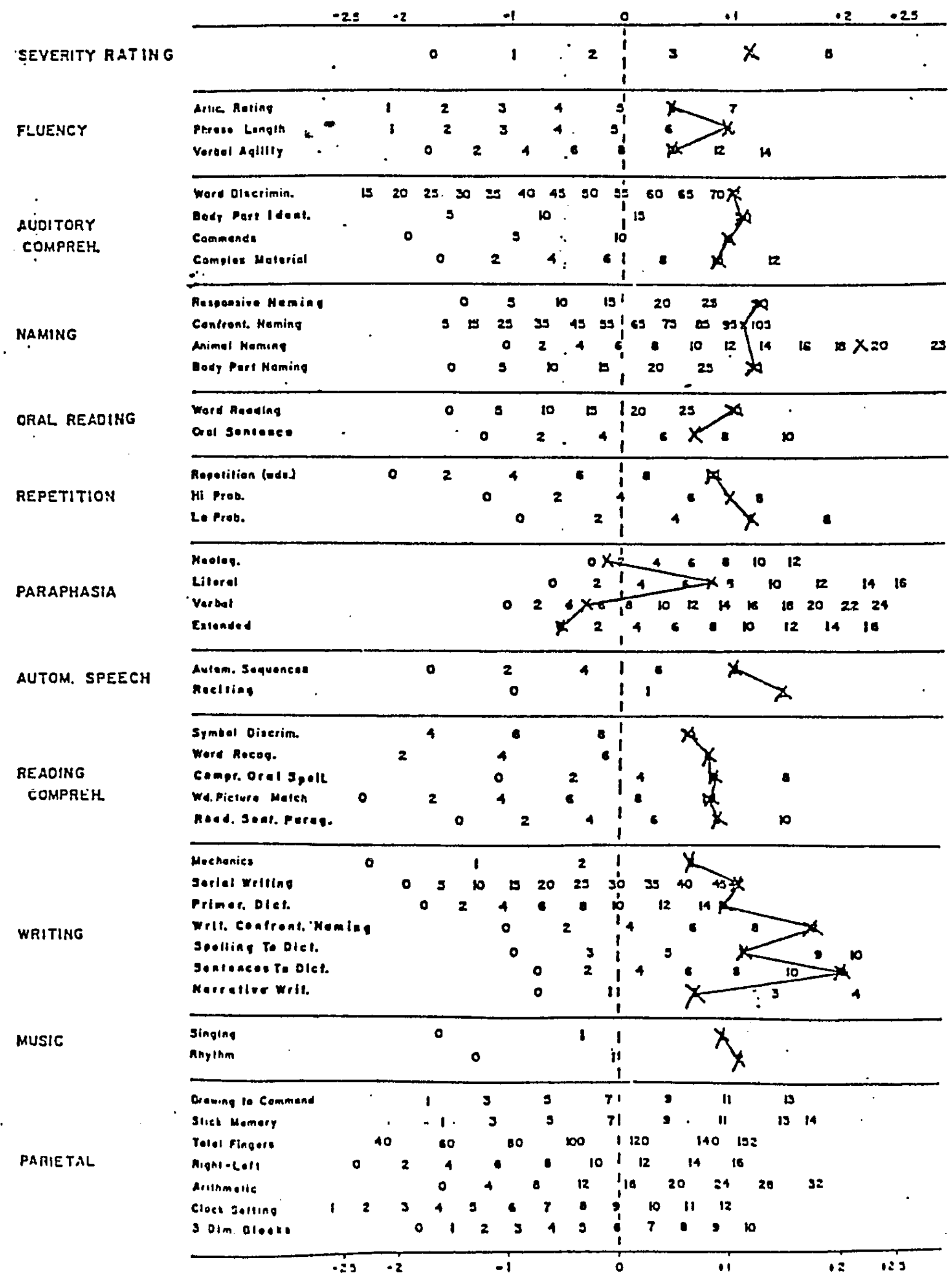
			Percent
A. Gesture Comprehension	(Max = 35)	< 34 >	97
1. Movement-Identification Test	(Max = 5)	5	100
2. Pantomime Recognition	(Max = 30)	29	97
B. Gesture Production	(Max = 115)	< 91 >	87.8
1. Nonrepresentational Movements			
a. Kimura Hand Posture Copying Test	(Max = 10)	8	80
b. Additional Hand Postures for Copying	(Max = 16)	6	38
c. Kimura Movement Copying Test	(Max = 24)	17	71
d. Additional Movements for Copying	(Max = 8)	7	88
2. Representaional Movements			
a. Buccofacial	(Max = 6)	5	83
b. Intransitive Limb	(Max = 12)	12	100
c. Transitive Limb	(Max = 12)	10	83
d. Whole Body Movements	(Max = 12)	11	92
3. Test of Kinesthetic Memory-Nonvisual	(Max = 10)	10	100
4. Test of Emotional Portrayal	(Max = 5)	5	100
C. Test of Kinesthetic Memory-Matching	(Max = 5)	5	100
D. Test of Visual Discrimination	(Max = 5)	5	100

*IMPAIRED PERFORMANCE

Z-SCORE PROFILE OF APHASIA SUBSCORES

NAME: AA

DATE OF EXAM:



Name: AA

Praxis Profile

Total Score = 138 = 86%

Maximum Score = 160

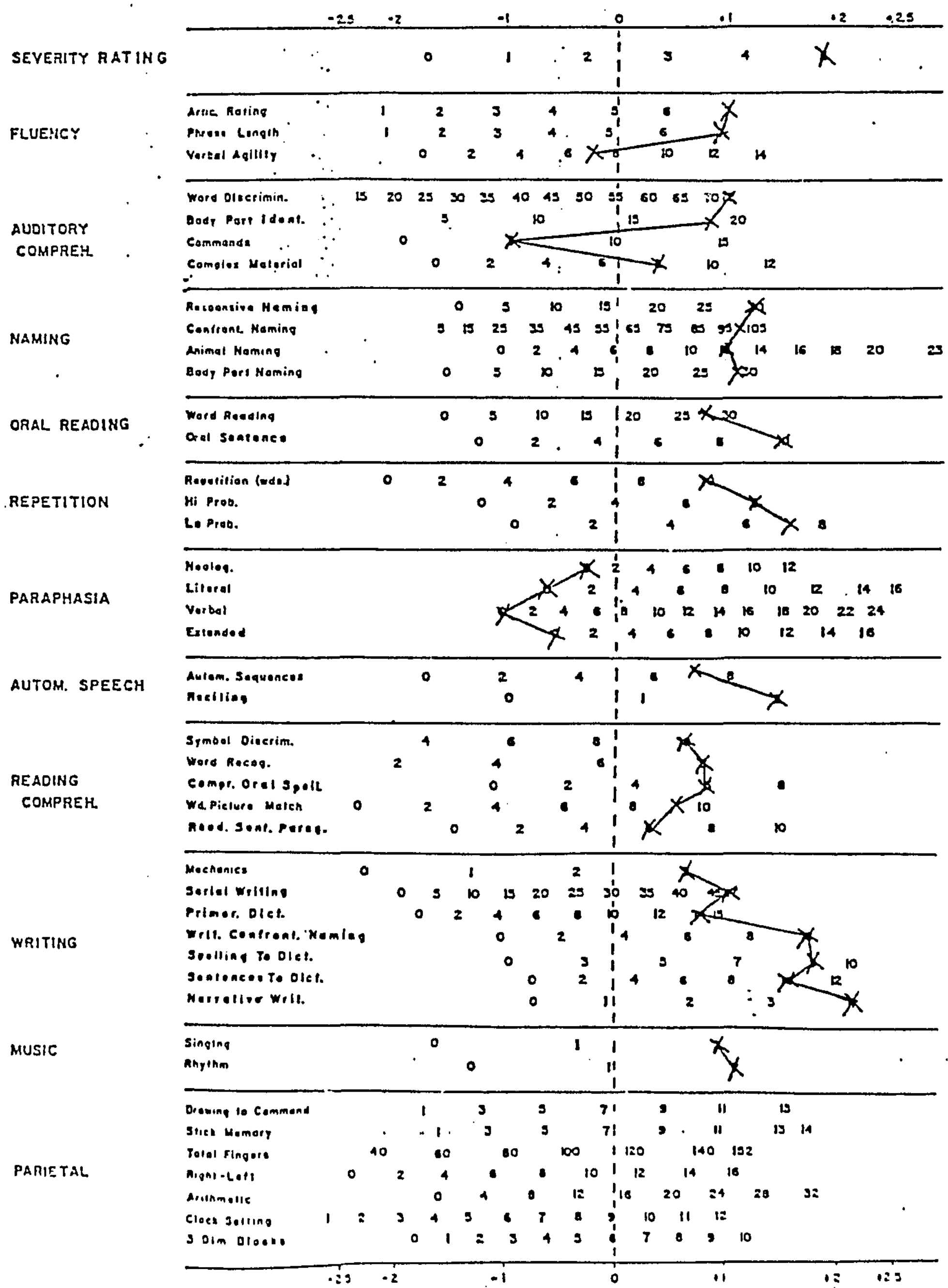
			Percent
A. Gesture Comprehension	(Max = 35)	< 34 >	97
1. Movement-Identification Test	(Max = 5)	4	80
2. Pantomime Recognition	(Max = 30)	30	100
B. Gesture Production	(Max = 115)	< 94 >	82
1. Nonrepresentational Movements			
a. Kimura Hand Posture Copying Test	(Max = 10)	9	90
b. Additional Hand Postures for Copying	(Max = 16)	14	88
c. Kimura Movement Copying Test	(Max = 24)	10*	42
d. Additional Movements for Copying	(Max = 8)	6	75
2. Representaional Movements			
a. Buccofacial	(Max = 6)	6	100
b. Intransitive Limb	(Max = 12)	12	100
c. Transitive Limb	(Max = 12)	12	100
d. Whole Body Movements	(Max = 12)	12	100
3. Test of Kinesthetic Memory-Nonvisual	(Max = 10)	8	80
4. Test of Emotional Portrayal	(Max = 5)	5	100
C. Test of Kinesthetic Memory-Matching	(Max = 5)	5	100
D. Test of Visual Discrimination	(Max = 5)	5	100

*IMPAIRED PERFORMANCE

Z-SCORE PROFILE OF APHASIA SUBSCORES

NAME: DJ

DATE OF EXAM:



Name: DJ

Praxis Profile

Total Score = 129.5 = 81%

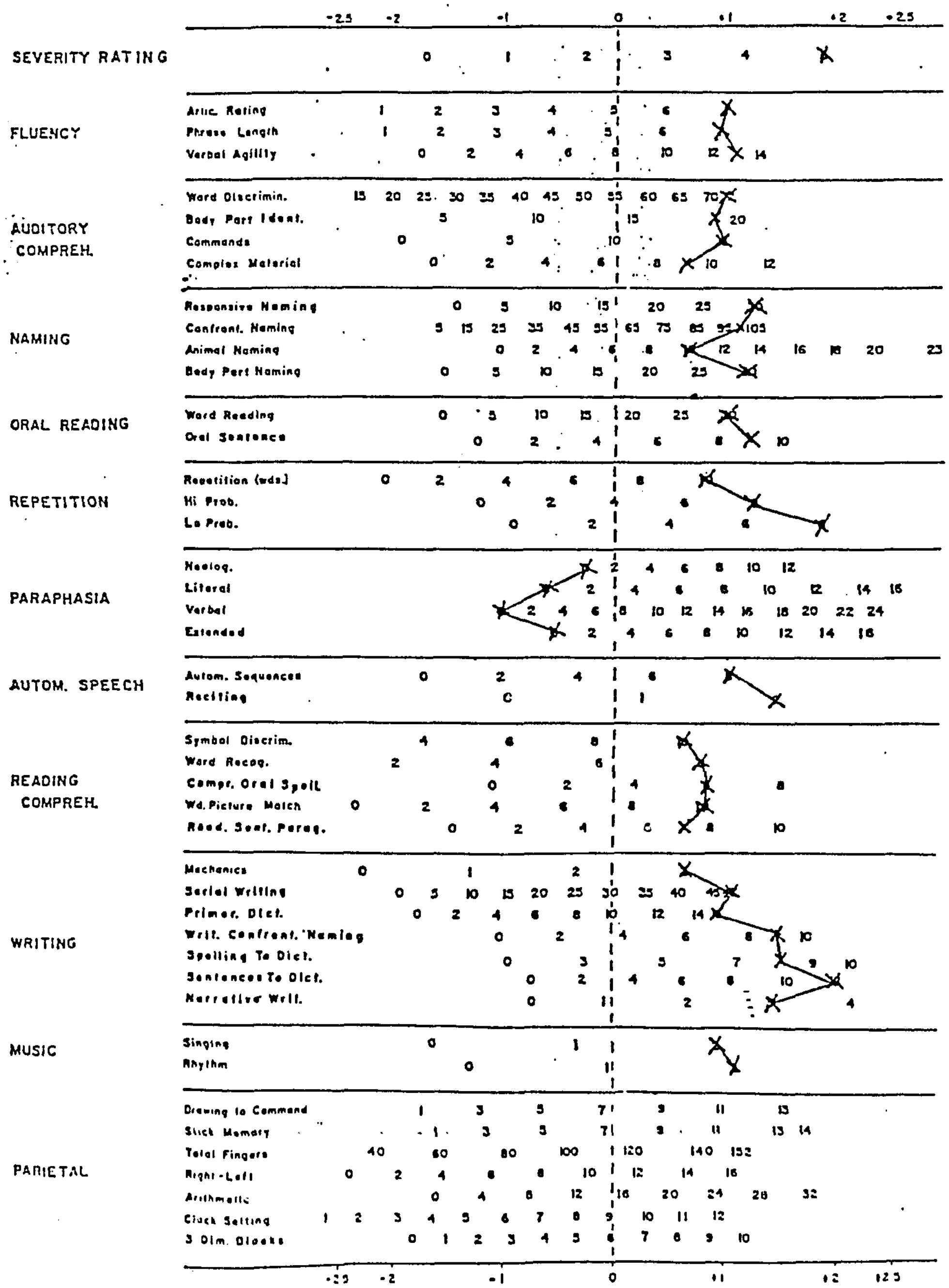
Maximum Score = 160

			Percent
A. Gesture Comprehension	(Max = 35)	(33)	94
1. Movement-Identification Test	(Max = 5)	4	80
2. Pantomime Recognition	(Max = 30)	29	97
B. Gesture Production	(Max = 115)	(87.5)	76
1. Nonrepresentational Movements			
a. Kimura Hand Posture Copying Test	(Max = 10)	10	100
b. Additional Hand Postures for Copying	(Max = 16)	11	69
c. Kimura Movement Copying Test	(Max = 24)	16*	67
d. Additional Movements for Copying	(Max = 8)	7	88
2. Representaional Movements			
a. Buccofacial	(Max = 6)	4	67
b. Intransitive Limb	(Max = 12)	11	92
c. Transitive Limb	(Max = 12)	9.5	79
d. Whole Body Movements	(Max = 12)	9	75
3. Test of Kinesthetic Memory-Nonvisual	(Max = 10)	6	60
4. Test of Emotional Portrayal	(Max = 5)	4	80
C. Test of Kinesthetic Memory-Matching	(Max = 5)	5	100
D. Test of Visual Discrimination	(Max = 5)	4	80

*IMPAIRED PERFORMANCE

Z-SCORE PROFILE OF APHASIA SUBSCORES

NAME: RB DATE OF EXAM:



Name: RB

Praxis Profile

Total Score = 153 = 96%

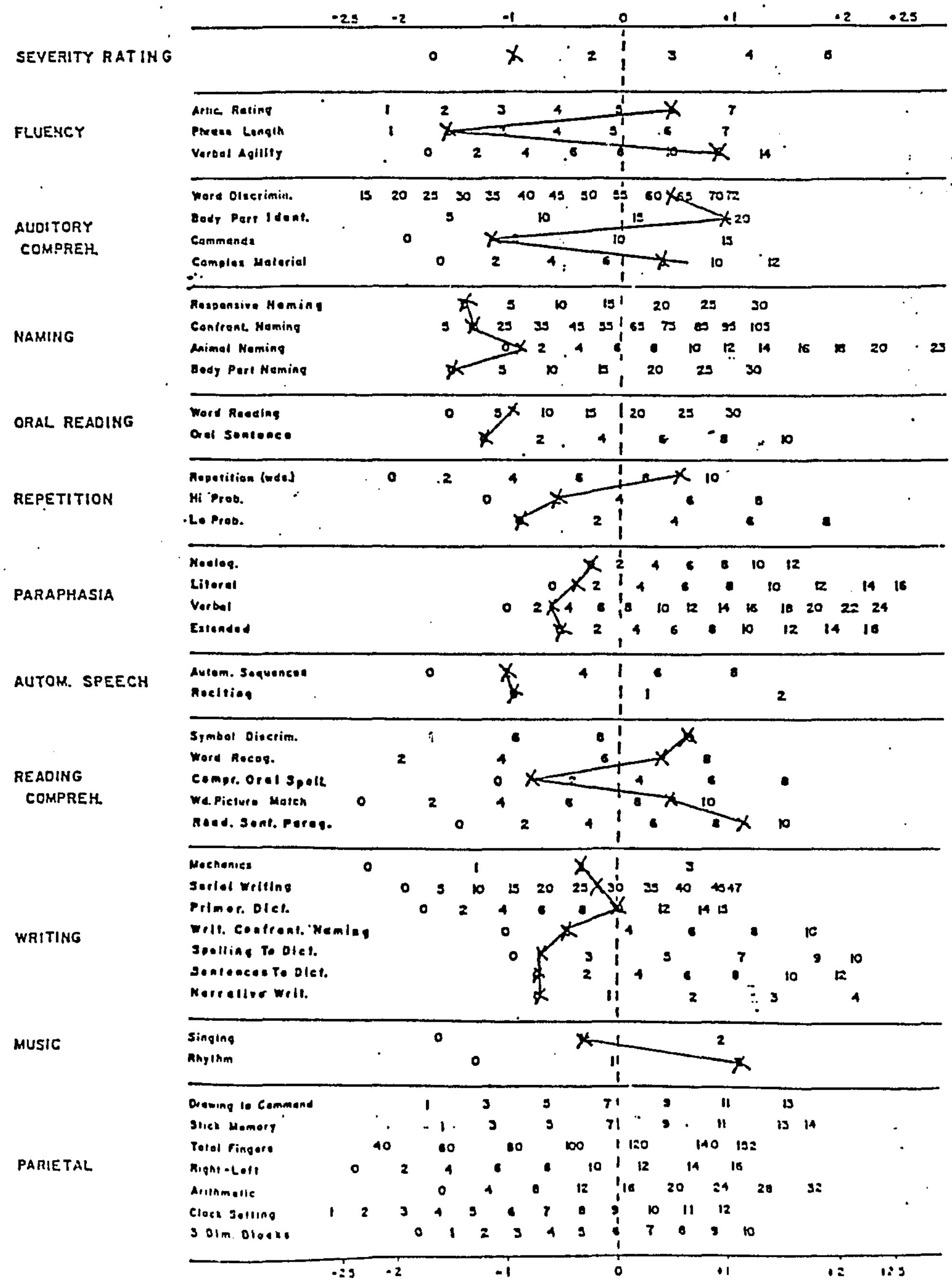
Maximum Score = 160

			Percent
A. Gesture Comprehension	(Max = 35)	(35)	100
1. Movement-Identification Test	(Max = 5)	5	100
2. Pantomime Recognition	(Max = 30)	30	100
B. Gesture Production	(Max = 115)	(108)	94
1. Nonrepresentational Movements			
a. Kimura Hand Posture Copying Test	(Max = 10)	10	100
b. Additional Hand Postures for Copying	(Max = 16)	13	81
c. Kimura Movement Copying Test	(Max = 24)	24	100
d. Additional Movements for Copying	(Max = 8)	8	100
2. Representaional Movements			
a. Buccofacial	(Max = 6)	6	100
b. Intransitive Limb	(Max = 12)	12	100
c. Transitive Limb	(Max = 12)	11	92
d. Whole Body Movements	(Max = 12)	9	75
3. Test of Kinesthetic Memory-Nonvisual	(Max = 10)	10	100
4. Test of Emotional Portrayal	(Max = 5)	5	100
C. Test of Kinesthetic Memory-Matching	(Max = 5)	5	100
D. Test of Visual Discrimination	(Max = 5)	5	100

*IMPAIRED PERFORMANCE

Z-SCORE PROFILE OF APHASIA SUBSCORES

NAME: MF DATE OF EXAM:



Name: MF

Praxis Profile

Total Score = 136 = 85%

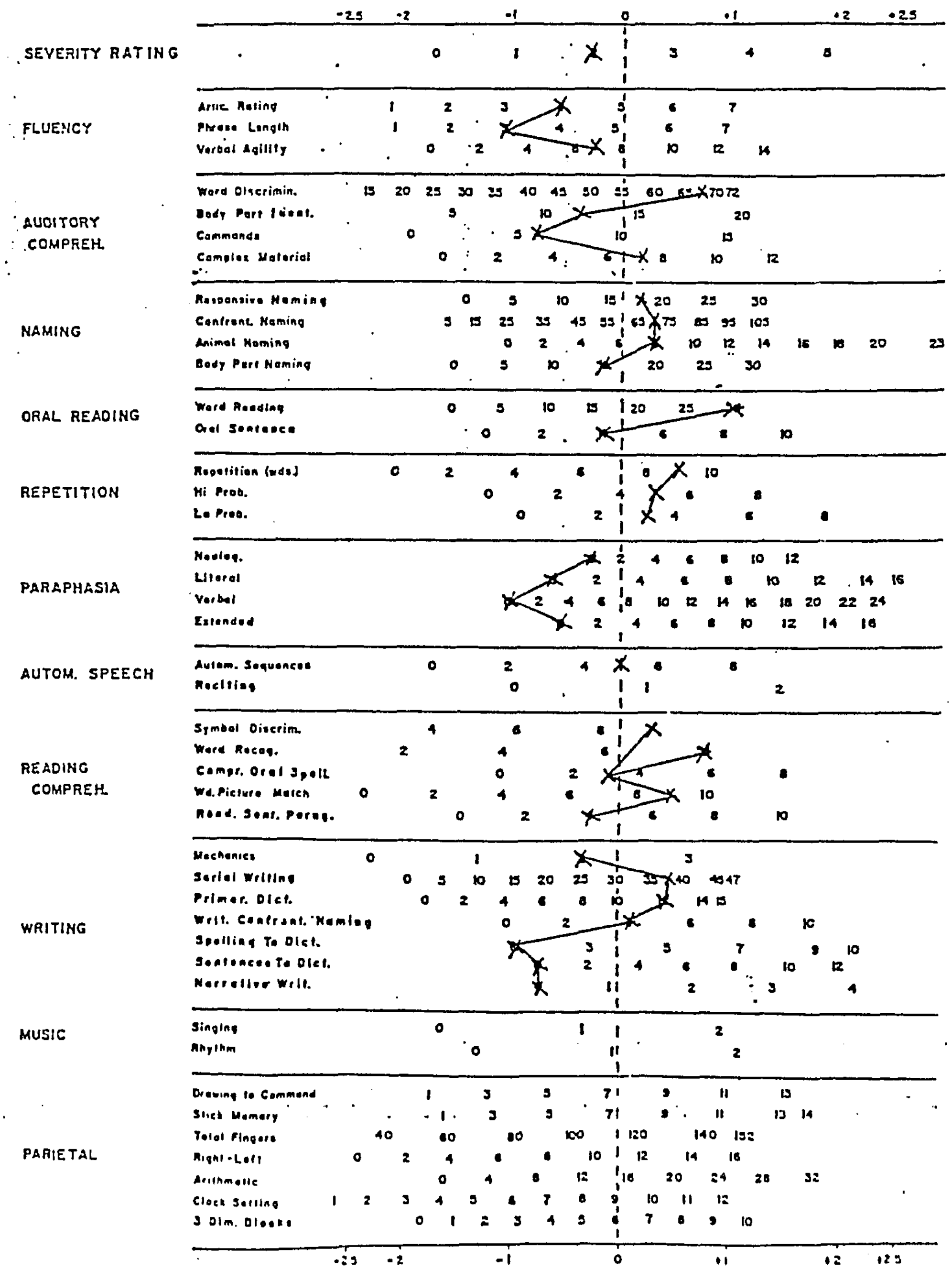
Maximum Score = 160

			Percent
A. Gesture Comprehension	(Max = 35)	⟨ 35 ⟩	100
1. Movement-Identification Test	(Max = 5)	5	100
2. Pantomime Recognition	(Max = 30)	30	100
B. Gesture Production	(Max = 115)	⟨ 101 ⟩	88
1. Nonrepresentational Movements			
a. Kimura Hand Posture Copying Test	(Max = 10)	10	100
b. Additional Hand Postures for Copying	(Max = 16)	16	100
c. Kimura Movement Copying Test	(Max = 24)	19	79
d. Additional Movements for Copying	(Max = 8)	7	88
2. Representaional Movements			
a. Buccofacial	(Max = 6)	5	83
b. Intransitive Limb	(Max = 12)	11	92
c. Transitive Limb	(Max = 12)	12	100
d. Whole Body Movements	(Max = 12)	6	50
3. Test of Kinesthetic Memory-Nonvisual	(Max = 10)	10	100
4. Test of Emotional Portrayal	(Max = 5)	5	100
C. Test of Kinesthetic Memory-Matching	(Max = 5)	5	100
D. Test of Visual Discrimination	(Max = 5)	5	100

*IMPAIRED PERFORMANCE

Z-SCORE PROFILE OF APHASIA SUBSCORES

NAME: SS DATE OF EXAM:



Name: SS

Praxis Profile

Total Score = 125 = 78%

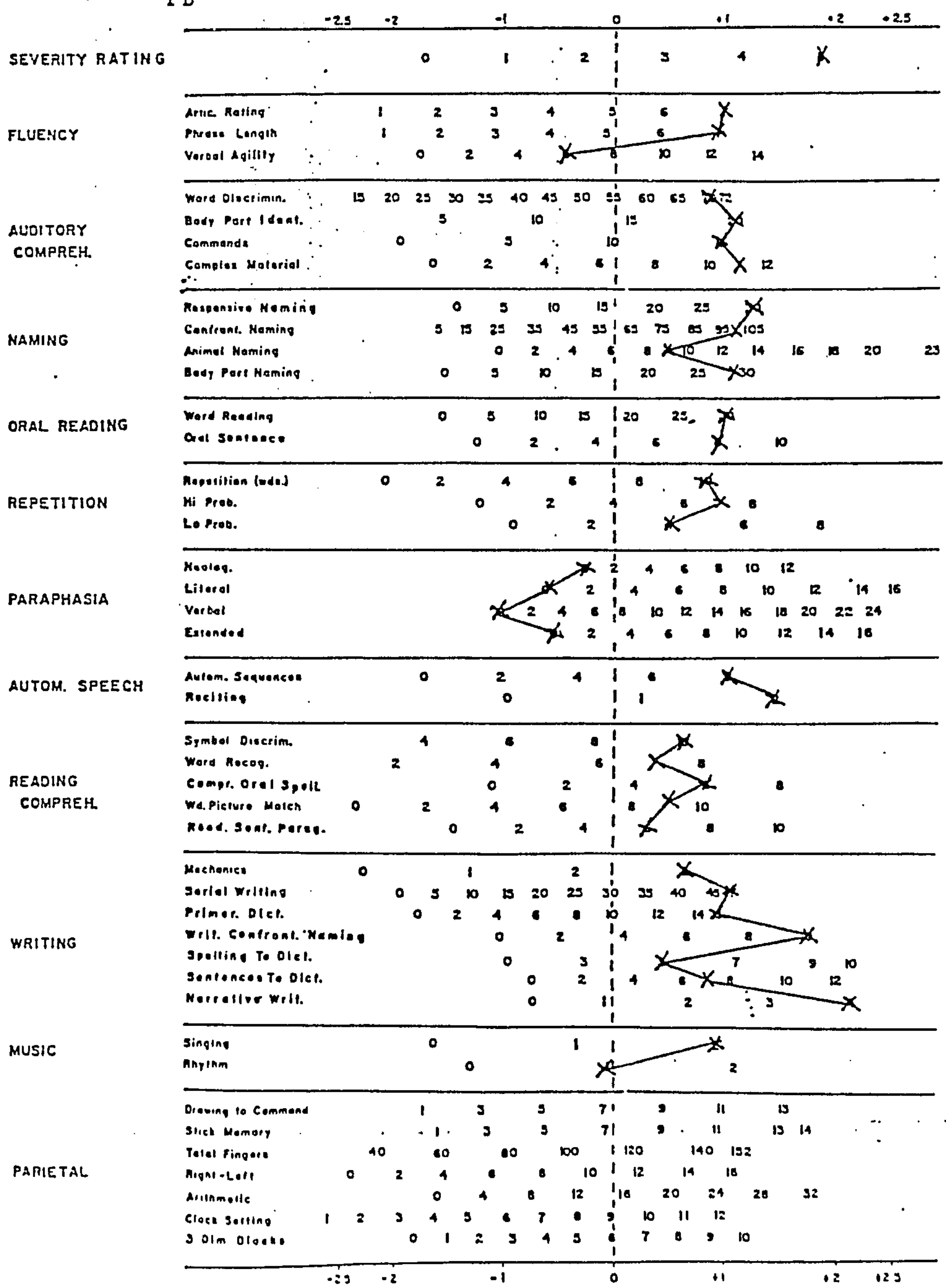
Maximum Score = 160

			Percent
A. Gesture Comprehension	(Max = 35)	(34)	97
1. Movement-Identification Test	(Max = 5)	5	100
2. Pantomime Recognition	(Max = 30)	29	97
B. Gesture Production	(Max = 115)	(81)	70
1. Nonrepresentational Movements			
a. Kimura Hand Posture Copying Test	(Max = 10)	8	80
b. Additional Hand Postures for Copying	(Max = 16)	14	88
c. Kimura Movement Copying Test	(Max = 24)	13*	54
d. Additional Movements for Copying	(Max = 8)	8	100
2. Representaional Movements			
a. Buccofacial	(Max = 6)	5	83
b. Intransitive Limb	(Max = 12)	9	75
c. Transitive Limb	(Max = 12)	8	67
d. Whole Body Movements	(Max = 12)	8	67
3. Test of Kinesthetic Memory-Nonvisual	(Max = 10)	6	60
4. Test of Emotional Portrayal	(Max = 5)	2	40
C. Test of Kinesthetic Memory-Matching	(Max = 5)	5	100
D. Test of Visual Discrimination	(Max = 5)	5	100

*IMPAIRED PERFORMANCE

Z-SCORE PROFILE OF APHASIA SUBSCORES

NAME: PB DATE OF EXAM:



Name: PB

Praxis Profile

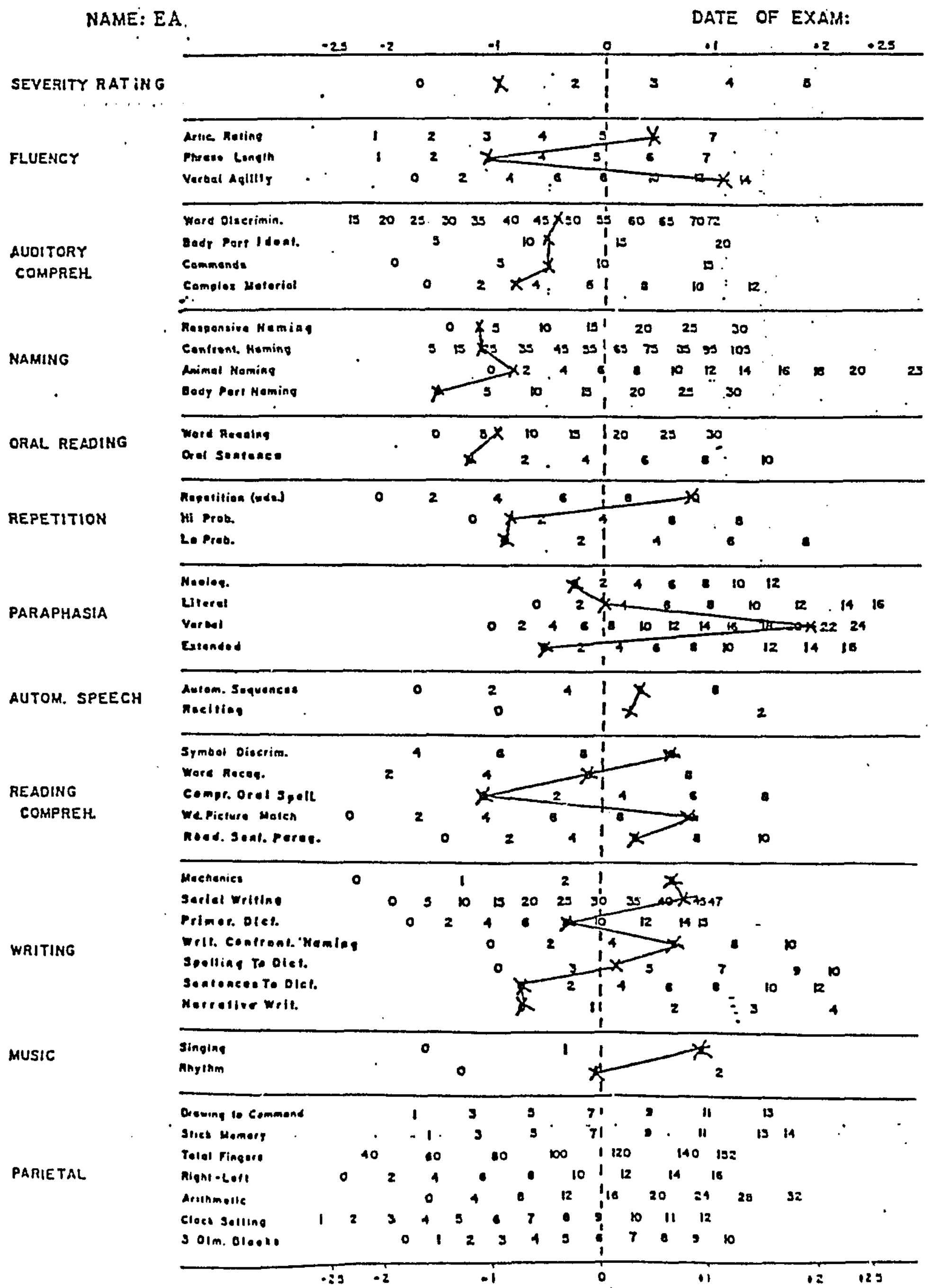
Total Score = 144 = 90%

Maximum Score = 160

			Percent
A. Gesture Comprehension	(Max = 35)	< 35 >	100
1. Movement-Identification Test	(Max = 5)	5	100
2. Pantomime Recognition	(Max = 30)	30	100
B. Gesture Production	(Max = 115)	< 101 >	88
1. Nonrepresentational Movements			
a. Kimura Hand Posture Copying Test	(Max = 10)	10	100
b. Additional Hand Postures for Copying	(Max = 16)	15	94
c. Kimura Movement Copying Test	(Max = 24)	16	67
d. Additional Movements for Copying	(Max = 8)	8	100
2. Representaional Movements			
a. Buccofacial	(Max = 6)	6	100
b. Intransitive Limb	(Max = 12)	11	92
c. Transitive Limb	(Max = 12)	12	100
d. Whole Body Movements	(Max = 12)	9	75
3. Test of Kinesthetic Memory-Nonvisual	(Max = 10)	10	100
4. Test of Emotional Portrayal	(Max = 5)	4	80
C. Test of Kinesthetic Memory-Matching	(Max = 5)	3	60
D. Test of Visual Discrimination	(Max = 5)	5	100

*IMPAIRED PERFORMANCE

Z-SCORE PROFILE OF APHASIA SUBSCORES



Name: EA

Praxis Profile

Total Score = 137 = 86%

Maximum Score = 160

			Percent
A. Gesture Comprehension	(Max = 35)	< 35 >	100
1. Movement-Identification Test	(Max = 5)	5	100
2. Pantomime Recognition	(Max = 30)	30	100
B. Gesture Production	(Max = 115)	< 92 >	80
1. Nonrepresentational Movements			
a. Kimura Hand Posture Copying Test	(Max = 10)	10	100
b. Additional Hand Postures for Copying	(Max = 16)	13	81
c. Kimura Movement Copying Test	(Max = 24)	16	67
d. Additional Movements for Copying	(Max = 8)	6	75
2. Representaional Movements			
a. Buccofacial	(Max = 6)	3	50
b. Intransitive Limb	(Max = 12)	9	75
c. Transitive Limb	(Max = 12)	12	100
d. Whole Body Movements	(Max = 12)	9	75
3. Test of Kinesthetic Memory-Nonvisual	(Max = 10)	10	100
4. Test of Emotional Portrayal	(Max = 5)	4	80
C. Test of Kinesthetic Memory-Matching	(Max = 5)	5	100
D. Test of Visual Discrimination	(Max = 5)	5	100

*IMPAIRED PERFORMANCE

References

Adams, J. (1971). A closed-looped theory of motor learning. Journal of Motor Behavior, 3, 111-149.

Adams, J., A., Marshall, P. H., Goetz, E. T. (1972). Response feedback and short-term motor retention. Journal of Experimental Psychology, 92, 92-95.

Alajouanine, T., & Lhermitte, F. (1964). Non-verbal communication in aphasia. In A. de Reuck & M. O'Conner (Eds.), Disorders of Language. London: Churchill.

Annett, M. (1970). A classification of hand preference by association analysis. British Journal of Psychology, 61, 303-321.

Barnes, S. van den Hoek (1973). The use of Sign Language as a technique for language acquisition in autistic children: An applied model bridging verbal and nonverbal theoretical systems. Dissertation Abstracts International, 34, 4651-B. (University Microfilms No. 74-7093,95).

Baker, C., & Padden, C. (1978). American Sign Language: A look at its history, structure, and community. Silver Spring, MD: T.J. Publishers.

Basso. A., Luzzatti, C., & Spinnler, H. (1980). Is ideomotor apraxia the outcome of damage to well-defined regions of the left hemisphere? Journal of Neurology, Neurosurgery, and Psychiatry, 43, 118-126.

Battison, R. (1980). Signs have parts: A simple idea. In C. Baker & R. Battison, Sign language and the deaf community. Silver Spring, MD: National Association of the Deaf.

Battison, R., Markowicz, A., & Woodward, J. (1975). A good rule of thumb: Variable phonology in American Sign Language. In R. Shuy & R. Fasold (Eds.), New ways of analyzing variation in English II. Washington, DC: Georgetown University Press.

Bellugi, U., & Klima, E. (1976). Two faces of sign: Iconic and abstract. In Harnad et al., (Eds.), Origins and evolution of language and speech (pp. 514-538). New York: Annals (280) of the New York Academy of Sciences.

Benson, D. F., & Geschwind, N. (1971). The aphasias and related disturbances. In A. Baker & L. Baker (Eds.), Clinical Neurology, Vol. 1. Hagerstown, MD: Harper & Row.

Benton, A. L., Hamsher, K. S., Varney, N. R., Spreen, O. (1983). Pantomime Recognition. In Contributions to neuropsychological assessment: A clinical manual. New York: Oxford University Press.

Benton, A. L., & Van Allen, M. W. (1970). Apraxia in relation to hemispheric locus of lesion and aphasia. Transactions of the American Neurological Association, 95, 147-150.

Bonvillian, J. D., & Friedman, R. J. (1978). Language development in another mode: The acquisition of signs by a brain-damaged adult. Sign Language Studies, 19, 111-120.

Borod, J. C., Goodglass, H., & Kaplan, E. (1980). Normative data on the Boston Diagnostic Aphasia Examination, Parietal Lobe Battery, and the Boston Naming Test. Journal of Clinical Neuropsychology, 2, 209-215.

Bower, G. T. (1984). Scripts in memory for text. Unpublished manuscript, Stanford University, Psychology Department, Stanford.

Boyes-Braem, P. (1973). A study of the acquisition of the DEZ in American Sign Language. Unpublished manuscript, The Salk Institute for Biological Studies, La Jolla, CA.

Broca, P. (1861). Remarques sur le siege de la faculte du langage articule, suivies d'une observation d'aphemie (perte de la parole). Bulletin de Societe de Anatomie, 36, 330-407.

Brookner, S. P., & Murphy, N., O. (1975). The use of a total communication approach with a nondeaf child: A case study. Language, Speech and Hearing Services in Schools, 6, 131-137.

Brown, J. (1972). Aphasia, apraxia, and agnosia. Springfield, Ill: Charles C. Thomas.

Brown, J. W., & Grober, E. (1983). Age, sex, and aphasia type: Evidence for a regional cerebral growth process underlying lateralization. The Journal of Nervous and Mental Disease, 171, 431-434.

Brown, R. (1978). Why are signed languages easier to learn than spoken languages? Part Two. Bulletin of the American Academy of Arts and Sciences, 32, 25-44.

Chen, L. (1968). "Talking hand" for aphasic stroke patients. Geriatrics, 23, 145-148.

Chomsky, N. (1972). Language and mind. New York: Harcourt Brace Jovanovich.

Christopoulou, C., & Bonvillian, J. D. (1985). Sign language, pantomime, and gestural processing in aphasic persons: A review. Journal of Communication Disorders, 18, 1-20.

Cicone, M., Wapner, W., Foldi, N., Zurif, E., & Gardner, H. (1979). The relation between gesture and language in aphasic communication. Brain and Language, 8, 324-349.

Code, C., & Gaunt, C. (1986). Treating severe speech and limb apraxia in a case of aphasia. British Journal of Disorders of Communication, 21, 11-20.

Coelho, C. A. (1982). An investigation of sign acquisition and use by severe, chronic aphasic subjects. Dissertation Abstracts International, 43, 2510-B. (University Microfilms No. 83-00, 123)

Craik, R. (1973). A levels of analysis view of memory. In P. Pliner, L. Kramer, & T. Alloway (Eds.), Communication and affect: Language and thought. New York: Academic Press.

Crittenden, J. (1974). Categorization of cheremic errors in Sign Language reception. Sign Language Studies, 5, 64-71.

Daniloff, J. K., Fritelli, G., Buckingham, H. W., Hoffman, P. R., & Daniloff, R. G. (1986). Amer-Ind versus ASL: Recognition and imitation in aphasic subjects. Brain Language, 28, 95-113.

Daniloff, J., Noll, J. D., Fristoe, M., Lloyd, L. (1982). Gesture recognition in patients with aphasia. Journal of Speech and Hearing Disorders, 47, 43-49.

Daniloff, J. K., & Vergara, D. (1984). Comparison between the motoric constraints for Amer-Ind and ASL sign formation. Journal of Speech and Hearing Research, 27, 76-88. Dee, H. L.,

Delis, D., Foldi, N. S., Hamby, S., Gardner, H., & Zurif, E. (1979). A note on temporal relations between language and gestures. Brain and Language, 8, 350-354.

Dennis, R., Reichle, J., Williams, W., & Vogelsberg, T. (1982). Motoric factors influencing the selection of vocabulary for sign production programs. The Association of Severely Handicapped Journal, 7, 20-32.

Denny-Brown, D. (1958). The nature of apraxia. Journal of Nervous and Mental Disorders, 126, 9-33.

DeRenzi, E., & Faglioni, P. (1978). Normative data and screening power of a shortened version of the Token Test. Cortex, 14, 41-49.

DeRenzi, E., Motti, F., & Nichelli, P. (1980). Imitating gestures: A quantitative approach to ideomotor apraxia. Archives of Neurology, 37, 6-10.

DeRenzi, E., Pieczuro, A., & Vignolo, L. A. (1968). Ideational apraxia: A quantitative study. Neuropsychologia, 6, 41-52.

DeRenzi, E., & Vignolo, L. A. (1962). The Token Test: A sensitive test to detect receptive disturbances in aphasics. Brain, 85, 665-678.

Disimoni, F. G. (1981). Therapies which utilize alternative or augmentative communication systems. In R. Chapey, Language Intervention Strategies in Adult Aphasia. New York: Williams & Wilkins.

Doherty, J. (1985). The effects of sign characteristics on sign acquisition and retention: An integrative review of the literature. Augmentative and Alternative Communication, 1, 108-121.

Doherty, J. E., & Lloyd, L. L. (1983, May). Effects of production mode, translucency and manuality on sign acquisition and recall by retarded adults. Paper presented at the meeting of the American Association on Mental Deficiency, Dallas.

Duffy, J. R. (1974). Comparison of brain injured and non brain injured subjects on an objective test of manual apraxia. Unpublished doctoral dissertation, University of Connecticut.

Duffy, R. J., & Duffy, J. R. (1981). Three studies of deficits in pantomimic expression and pantomimic recognition in aphasia. Journal of Speech and Hearing Research, 46, 70-84.

Duffy, R. J., Duffy, J. R., & Mercaitis, P. A. (1984). Comparison of the performances of a fluent and non-fluent aphasic on a pantomimic referential task. Brain and Language, 21, 260-273.

Duffy, R. J., Duffy, J. R., & Pearson, K. (1975). Pantomime recognition in aphasics. Journal of Speech and Hearing Research, 18, 115-132.

Duffy, R. J., Duffy, J. R., Uryase, E., & Merritt, D. D. (1982, November). Aphasic pantomime recognition deficits as a visual modality disorder. Paper presented at the annual convention of the American Speech-Language Hearing Association, Toronto, Canada.

Duffy, R. J., & Liles, B. Z. (1979). A translation of Finkelnburg's (1870) lecture on aphasia as "asymbolia" with commentary. Journal of Speech and Hearing Research, 44, 156-168.

Duffy, R. J., & McEwen, W. J. (1978). A study of the relationship between pantomime symbolism and pantomime recognition in aphasics. Folia Phoniatrica, 30, 286-292.

Duffy, J. R., & Watkins, L. B. (1984). The effect of response choice relatedness on pantomime and verbal recognition ability in aphasic patients. Brain and Language, 21, 291-306.

Eagleson, H. M., & Knudson, A., B. (1970). Hand signals for dysphasia. Archives of Physical Medicine and Rehabilitation, 51, 111-113.

Ettlinger, G. (1969). Apraxia considered as a disorder of movements that are language dependent: Evidence from cases of brain dissection. Cortex, 5, 285-289.

Fawcett, G. F., & Clibbens, J. S. (1983). The acquisition of signs by the mentally handicapped: Measurement criteria. British Journal for Disorders in Communication, 18, 13-21.

Ferro, J. M., Santos, M. E., Castro-Caldas, A. & Mariano, M. G. (1980). Gesture recognition in aphasia. Journal of Clinical Neuropsychology, 2, 277-292.

Feyereisen, P., Seron., X. (1982). Nonverbal communication and aphasia: A review. Brain and Language, 16, 191-236.

Fink, M., Green, M., Bender, M. B. (1952). The face-hand test as a diagnostic sign of organic mental syndrome. Neurolcgy, 2, 46-58.

Foldi, N. S., Cicone, M., & Gardner, H. (1982). Pragmatic aspects of communication in brain damaged patients. Unpublished manuscript, Clark University.

Fouts, R. S. (1972). Use of guidance in teaching sign language to a chimpanzee (Pan troglodytes). Journal of Comparative and Physiological Psychology, 80, 515-522.

Fouts, R. S. (1973). Acquisition and testing of gestural signs in four young chimpanzees. Science, 180, 978-980.

Fristoe, M.. Lloyd, L. L. (1979). Signs used in manual communication training with persons having severe communication impairment. American Association for the Education of the Severely/Profoundly Handicapped, 4, 364-373.

Fristoe, M., & Lloyd, L. L. (1980). Planning an initial expressive sign lexicon for persons with severe communication impairment. Journal of Speech and Hearing Disorders, 45, 170-180.

Gainotti, G., & Lemmo, M. (1976). Comprehension of symbolic gestures in aphasia. Brain and Language, 3, 451-460.

Gardner, B. T., & Gardner, R. A. (1971). Two-way communication with an infant chimpanzee. In A. M. Schrier & F. Stollnitz (Eds.), Behavior of nonhuman primates, (Vol. 4). New York: Academic Press.

Gardner, H., Zurif, E. B., Berry, T., & Baker, E. (1976). Visual communication in aphasia. Neuropsychologia, 14, 275-292.

Geschwind, N. (1975). The apraxias: Neural mechanisms of disorders of learned movement, The American Scientist, 63, 188-195.

Gesell, A., & Amatruda, C. S. (1941). Developmental diagnosis. New York: Hoeber Medical Book Dept., Harper & Row.

Glass, A., Gazzaniga, M., & Premack, D. (1973). Artificial language training in global aphasics. Neuropsychologia, 11, 95-103.

Goldstein, K. (1948). Language and language disturbances. New York: Grune & Stratton.

Goldstein, K. (1970). Hugo Liepmann. In W. Haymaker & F. Schiller (Eds.), The founders of neurology (2nd ed., pp. 473-476). Springfield, Ill: Charles C. Thomas.

Gonzalez-Rothi, L. J., Heilman, K. M., Mack, L., Verfaille, M., & Brown, P. C. (in press). Ideomotor apraxia: Error pattern analysis. Aphasiology.

Goodglass, H., & Kaplan, E. (1963). Disturbances of gesture and pantomime in aphasia. Brain, 86, 703-720.

Goodglass, H., & Kaplan, E. (1972). Assessment of aphasia and related disorders. Philadelphia: Lea & Febiger.

Grinnell, M. F., Detamore, K. L., Lippke, B. A. (1976). Sign it successful: Manual English encourages expressive communication. Teaching Exceptional Children, 8, 123-124.

Guilford, J. P. (1965). Fundamental statistics in psychology and education. New York: McGraw-Hill.

Haaland, K. Y., & Flaherty, D. (1984). The different types of limb apraxia errors made by patients with left versus right hemisphere damage. Brain and Cognition, 3, 370-384.

Halverson, H. M. (1931). An experimental study of prehension in infants by means of systematic cinema records. Genetic Psychology Monographs, 10, 107-286.

Head, H. (1926). Aphasia and kindred disorders of speech (Vol. 1). New York: MacMillan.

Hécaen, H. (1967). Approché semiolique des troubles de geste. Languages, 5, 67-83.

Hécaen, H., Albert, M. (1978). Human neuropsychology. New York: Wiley.

Hécaen, H., & Rondot, P. (1985). Apraxia as a disorder of a system of signs. In E. A. Roy (Ed.) Neuropsychological studies of apraxia and related disorders (pp. 75-97). Amsterdam: Elsevier.

Heilman, K. (1979). Apraxia. In K. Heilman & E. Valenstein (Eds.), Clinical neuropsychology. New York: Oxford University Press.

Heilman, K. M., Rothi, L., Campanella, D., & Wolfson, S. (1979). Wernicke's and global aphasia without alexia. Archives of Neurology, 36, 129-133.

Heilman, K. M., Rothi, L. J., & Valenstein, E. (1982). Two forms of ideomotor apraxia. Neurology, 32, 342-346.

Heilman, K. M., Schwartz, H. D., & Geschwind, N. (1975). Defective motor learning in ideomotor apraxia. Neurology, 25, 1018-1020.

Helm-Estabrooks, N., Fitzpatrick, P. M., & Barresi, B. (1982). Visual action therapy for global aphasia. Journal of Speech and Hearing Disorders, 47, 385-389.

Holmes, J. M. (1975, October). Manual signing with an aphasic patient. Paper presented at the 13th Academy of Aphasia meeting, Victoria, British Columbia, Canada.

Holmes, K., & Holmes, D. (1980). Signed and spoken language development in a hearing child of hearing parents. Sign Language Studies, 28, 239-254.

Humphries, T., Padden, C., & O'Rourke, T. J. (1980). A basic course in American Sign Language. Silver Spring, MD: T. J. Publishers.

Jackson, H. (1932). On affectations of speech from disease of the brain. In J. Taylor (Ed.), Selected Writings of John Hughlings Jackson, (Vol. 2, pp. 155-170). London: Hodder & Stroughton. (Original work published 1878)

Jason, G. W. (1985). Manual sequence learning after focal cortical lesions. Neuropsychologia, 23, 483-496.

Jenkins, J., Jimenez-Pabon, E., Shaw, R., & Sefer, J. (1975). Schuells's aphasia in adults: Diagnosis, prognosis, and treatment. Hagerstown, MD: Harper & Row.

Johannsen-Horbach, H., Cegla, B., Mager, U., & Schempp, B. (1985). Treatment of chronic global aphasia with a nonverbal communication system. Brain and Language, 24, 74-82.

Kadish, J. (1978). A neuropsychological approach to the study of gesture and pantomime in aphasia. The

South African Journal of Communication Disorders, 25, 102-117.

Kantor, R. (1980). The acquisition of classifiers in American Sign Language, Sign Language Studies, 28, 193-208.

Kellog, W. N. (1968). Communication in language in the home-raised chimpanzee. Science, 162, 423-427.

Kertesz, A., Ferro, J. M. (1984). Lesion size and location in ideomotor apraxia. Brain, 107, 921-933.

Kertesz, A., & Hooper, P (1982). Praxis and language: The extent and variety of apraxia in aphasia. Neuropsychologia, 20, 275-286.

Kimura, E. (1973). Manual activity during speaking. Neuropsychologia, 11, 45-55.

Kimura, D. (1976). The neural basis of language qua gesture. In H. Whitaker & H. Whitaker (Eds.), Studies in neurolinguistics, (Vol. 2, pp. 145-156). New York: Academic Press.

Kimura, D. (1977). Acquisition of a motor skill after left hemisphere damage. Brain, 100, 527-542.

Kimura, D. (1979). Neuromotor mechanisms in the evolution of human communication. In H. D. Stecklis & M. J. Raleigh (Eds.), Neurobiology of social communication in primates. New York: Academic Press.

Kimura, D. (1980). Translations from Liepmann's Essays on apraxia (Research Bulletin No. 506). London, Ontario, Canada: University of Western Ontario, Department of Psychology.

Kimura, D. (1981). Neural Mechanisms in Manual Signing. Sign Language Studies, 33, 291-312.

Kimura, D. (1982). Left-hemisphere control of oral and brachial movements and their relation to communication. Philosophical Transactions of the Royal Society of London, B298, 135-149.

Kimura, D., & Archibald, Y. (1974). Motor functions of the left hemisphere. Brain, 97, 337-350.

Kirk, R. E. (1968). Experimental design procedures for the behavioral sciences. Belmont, California: Brooks/Cole.

Kirshner, H. S., & Webb, W. G. (1981). Selective involvement of the auditory-verbal modality in an acquired communication disorder: Benefit from sign language therapy. Brain and Language, 13, 161-170

Klima, E. S., & Bellugi, U. (1979). The signs of language. Cambridge, Mass.: Harvard University Press.

Kohl, F. L. (1981). Effects of motoric requirements on the acquisition of manual sign responses by severely handicapped students. American Journal of Mental Deficiency, 85, 396-403.

Kolb, B., & Milner, B. (1981). Performance of complex arm and facial movements after focal brain lesions. Neuropsychologia, 19, 491-503.

Konstantareas, M. M., Oxman, J., & Webster, C. D. (1978). Iconicity: Effects on the acquisition of Sign Language by autistic children. In P. Siple (Ed.), Understanding language through Sign Language research. New York: Academic Press.

Lane, H. (1976). The wild boy of Aveyron. Cambridge, MA: Harvard University Press.

Lehmkuhl, G., Poeck, K., & Willmes, K. (1983). Ideomotor apraxia and aphasia: An examination of types and manifestations of apraxic symptoms. Neuropsychologia, 21, 199-212.

Levin, H. S., Benton, A. L., Grossman, R. G. (1982). Neurobehavioral consequences of closed head injury. New York: Oxford University Press.

Lezak, M. D. (1983). Neuropsychological assessment. New York: Oxford University Press.

Liepmann, H. (1977). The syndrome of apraxia (motor asymboly) based on a case of unilateral apraxia. In D. Rottenberg & F. H. Hochberg (Eds.), Neurological classics in modern translation, (pp. 155-183). New York: Hafner Press. (Reprinted from Monatschrift fur Psychiatrie und Neurologie, 1900, 8, 15-44)

Lloyd, L. L., & Doherty, J. E. (1983). The influence of production mode on the recall of signs in normal adult subjects. Journal of Speech and Hearing Research, 26, 595-600.

Luftig, R. L., & Lloyd, L. L. (1981). Manual sign translucency and referential concreteness in the learning of signs. Sign Language Studies, 30, 49-60.

Luftig, R. L., Lloyd, L. L., Page, J. L. (1982). Ratings of sign translucency and gloss concreteness of two grammatical classes of signs. Sign Language Studies, 37, 305-343.

Luftig, R. L., Page, J. L., & Lloyd, L. L. (1983). Ratings of perceived translucency in manual signs as a predictor of sign learnability. Journal of Children with Communication Disorders, 6, 117-134.

Luria, A. (1973). The working brain. New York: Penguin Press.

Marshall, J. C. (1980). Clues from neurological deficits. In U. Bellugi & M Studdert-Kennedy (Eds.), Signed and spoken language: Biological constraints on linguistic form, (pp. 275-290). Dahlem Konferenzen, Weinheim: Verlag Chemie GmbH.

McIntire, M. (1977). The acquisition of American Sign Language hand configurations. Sign Language Studies, 16, 247-266.

Musselwhite, C. R., & St. Louis, K. W. (1982). Communication programming for the severely handicapped. San Diego: College-Hill.

Norman, D., & Rumelhart, D. (1970). A system for perception and memory. In D. Normal (Ed.), Models of human memory. New York: Academic Press.

O'Rourke, T. J. (1973). A basic course in manual communication. Silver Spring, ND: National Association of the Deaf.

Peng, F. C. C. (1978). Sign language and language acquisition in man and ape. New dimensions in comparative pedolinguistics. Boulder: West View Press.

Peters, L. J. (1974) Sign language stimulus in vocabulary learning of a brain-injured child. Sign Language Studies, 3, 116-117.

Peterson, L. N., & Kirshner, H. S. (1981). Gestural impairment and gestural ability in aphasia: A review. Brain and Language, 14, 333-348.

Pickett, L. W. (1974). An assessment of gestural and pantomimic deficit in aphasic patients. Acta Symbolica, 5, 69-86.

Poizner, H., Battison, R., & Lane, H. (1979). Cerebral asymmetry for American Sign Language: The effects of moving stimuli. Brain and Language, 7, 351-362.

Poizner, H., Bellugi, U., & Iragui, V. (in press). Apraxia and aphasia for a visual-gestural language. American Journal of Physiology.

Poizner, H., & Lane, H. (1979). Cerebral asymmetry in the perception of American Sign Language. Brain and Language, 7, 210-226.

Rao, P. (1985). An investigation into the neuropsychological bases of gesture in brain-injured adults. Doctoral Dissertation, University of Maryland, College Park.

Rao, P. (1986, October). A neuropsychological review of gesture in brain-injured adults. Paper presented at the meeting of the Maryland Speech and Hearing Association, College Park, MD.

Rao, P., R., & Horner, J. (1978). Gesture as a deblocking modality in a severe aphasic patient. In R. Brookshire (Ed.), Clinical Aphasiology, Conference

Proceedings (pp. 180-185). Minneapolis: BRK Publishers.

Rose, F. C. (Ed.) (1984). Advances in neurology. Progress in aphasiology (Vol. 42). New York: Raven Press.

Rothi, L. J. G., & Heilman, K. M. (1984). Acquisition and retention of gestures by apraxic patients. Brain and Language, 3, 426-437.

Rothi, L. J. G., Heilman, K. M., & Watson, R. T. (1985). Pantomime comprehension and ideomotor apraxia. Journal of Neurology, Neurosurgery, and Psychiatry, 48, 207-210.

Sarno, M. T., & Hook, O. (1980). Aphasia assessment and treatment. In Review of research in aphasia: Recovery and rehabilitation. Stockholm: Almqvist & Wiksell International.

Schmidt, R. A. (1975). A schema theory of discrete motor skill learning. Psychological Review, 82, 225-260.

Selnes, X., Rubens, A., Risse, G., & Levy, R. (1982). Transient aphasia with persistent apraxia: Uncommon sequela of massive left-hemisphere stroke. Archives of Neurology, 39, 122-126.

Seron, Van Der Kaa, M. A., Remitz, A., & Van Der Linden, M.(1979). Pantomime interpretation and aphasia. Neuropsychologia, 17, 661-668.

Shaeffer, B. (1980). Spontaneous language through signed speech. In R. L. Schiefelbusch (Ed.), Nonspeech language and communication. Baltimore: University Park Press.

Shane, H. C., & Wilbur, R. B. (1980). Potential for expressive signing based on motor control. Sign Language Studies, 29, 331-348.

Siegel, S., & Casterline, N. J. (1988). Nonparametric statistics for the behavioral sciences (2nd ed.). New York: McGraw-Hill.

Silverman, F. (1980). Communication for the speechless.

Englewood Cliffs, NJ: Prentice Hall.

Skelly, M. (1979). Amer-Ind gestural code based on universal American Indian hand talk. New York: Elsevier.

Skelly, M., Schinsky, L., Smith, R. W., & Fust, R. S. (1974). American Indian Sign (Amerind) as a facilitator of verbalization for the oral verbal apraxic. Journal of Speech and Hearing Disorders, 39, 445-456.

Stokoe, W. C. (1960). Sign language structure: Studies in linguistics. Occasional papers 8. Buffalo: University of Buffalo Press.

Stokoe, W. C., Casterline, D. C., & Croneberg, C. G. (1976). A dictionary of American Sign Language: On linguistic principles. Silver Spring, MD: Linstok Press.

Stremel-Campbell, K., Cantrell, D., & Halle, J. (1977). Manual signing as a language system and as a speech initiator for the nonverbal severely handicapped student. In E. Sontag, J. Smith, N. Certo (Eds.), Educational Programming for the severely and profoundly handicapped (pp. 335-347). Reston, Virginia: Division on Mental Retardation, Council for Exceptional Children.

Stuart-Smith, V. G., & Wilks, V. (1979). Gesture program: A supplement to verbal communication for severely aphasic individuals. Australian Journal of Human Communication Disorders, 7, 37-50.

Sukiennicki, A. (1971). Neuromotor development. In B. S. Banus (Ed.), The developmental therapist. Thorofare, NJ: Charles B. Slack.

Sutherland, D., & Kates, B. (1975). Considerations in assessing a child's communication needs. Unpublished manuscript, Ontario Crippled Children's Centre, Ontario, Canada.

Varney, N. R. (1978). Linguistic correlates of pantomime recognition in aphasic patients. Journal of Neurology, Neurosurgery, and Psychiatry, **41**, 564-568.

Varney, N. R. (1982). Pantomime recognition in aphasia: Implications for the concept of asymbolia. Brain and Language, 15, 32-39.

Varney, N. R. & Benton A. L. (1982). Qualitative aspects of pantomime recognition defect in aphasia. Brain and Cognition, 1, 132-139.

Weigl, E. (1974) Neuropsychological experiments on transcoding between spoken and written language structures. Brain and Language, 1, 240-277.

Wilbur, R. (1979). American Sign Language and sign systems. Baltimore: University Park Press.

Wilbur, R., & Jones, M. (1974). Some aspects of the bilingual/bimodal acquisition of American Sign Language and English by three hearing children of deaf parents. In LaBaly, Fox, & Bruck (Eds.), Papers From the Tenth Regional Meeting of the Chicago Linguistics Society (pp. 742-749). Chicago: Chicago Linguistics Society.