

Speech Understanding Systems

Final Report of a Study Group

Allen NEWELL

*Carnegie-Mellon University
Pittsburgh, Pennsylvania*

Jeffrey BARNETT

*System Development Corporation
Santa Monica, California*

James W. FORGIE

*MIT Lincoln Laboratory
Lexington, Massachusetts*

Cordell GREEN

*Stanford University
Stanford, California*

Dennis KLATT

*Massachusetts Institute of Technology
Cambridge, Massachusetts*

J. C. R. LICKLIDER

*MIT Project MAC
Cambridge, Massachusetts*

John MUNSON

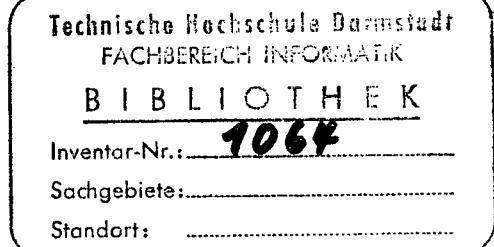
*Stanford Research Institute
Menlo Park, California*

D. Raj REDDY

*Carnegie-Mellon University
Pittsburgh, Pennsylvania*

William A. WOODS

*Bolt, Beranek and Newman
Cambridge, Massachusetts*



1973

NORTH-HOLLAND PUBLISHING COMPANY - AMSTERDAM • LONDON
AMERICAN ELSEVIER PUBLISHING COMPANY, INC. - NEW YORK

TABLE OF CONTENTS

PREFACE	
1. CONCLUSIONS AND RECOMMENDATIONS	1
2. INTRODUCTION	4
3. THE USES OF SPEECH INPUT	7
4. ORIENTATION OF THE STATE OF THE ART	9
5. TASKS FOR STUDY	13
5.1 Querying a Data Management System	13
5.2 Data Acquisition of Formatted Information	15
5.3 Querying the Operational Status of a Computer	15
5.4 Consulting on the Operation of a Computer	18
6. ANALYSIS OF THE TASKS	21
6.1 System Organization	21
6.2 Semantic Level	21
6.3 Sentence Level	23
6.4 Lexical Level	24
6.5 Phonemic Level	25
6.6 Parametric Level	26
6.7 Acoustic Level	27
6.8 Conclusion	27
7. TECHNICAL PROBLEMS AND PROSPECTS	28
7.1 The Continuous Speech Problem	28
7.2 The Multiple Speaker Problem	28
7.3 The Speaker Dialect Problem	28
7.4 The Environmental Noise Problem	29
7.5 The Telephone Problem	29
7.6 The Tuneability Problem	29
7.7 The User Training Problem	30
7.8 The Vocabulary Problem	30
7.9 The Syntactic Support Problem	30
7.10 The Semantic Support Problem	31
7.11 The User Model Problem	31
7.12 The Interaction Problem	31
7.13 The Reliability Problem	32
7.14 The Real Time Problem	32
7.15 The Processing Power Problem	32
7.16 The Memory Problem	33
7.17 The Systems Organization Problem	33

7.18	The Cost Problem	33
7.19	The Completion Date Problem	33
7.20	A Target System	34
8.	WAYS AND MEANS	35
8.1	The Plan	35
8.2	Specification of Initial Research	37
8.3	Cooperative Endeavor, Control and Public Information	39
8.4	Requirements for the Contractors Developing the Target System	41

APPENDICES

A1.	HISTORY AND STAFFING OF THE STUDY GROUP	43
A2.	INTRODUCTION TO SPEECH	45
A3.	DATA ON HUMAN PROCESSING RATES	50
A4.	VOICE-DM	52
A4.1	DS/2 Extensions for Speech Input	52
A4.2	Protocol of Voice-DM	53
A4.3	Syntax for (Written) DS/2	54
A5.	VOICE-KP - DESCRIPTION AND EXPERIMENT	57
A5.1	System Design	57
A5.2	Results of the Experiment	61
A5.3	Discussion	61
A6.	VOICE-CS	64
A6.1	The Data Base	64
A6.2	Input Vocabulary	64
A6.3	Input Syntax	64
A6.4	Protocol	66
A7.	VOICE-CC	69
A7.1	Recorded Protocol for Voice-CC	69
A8.	OTHER POSSIBLE TASKS FOR SPEECH-UNDERSTANDING SYSTEMS	72
A9.	ANALYSIS OF THE TASKS	73
A9.1	System Organization	73
A9.2	Semantic Level	83
A9.2.1	Simulation of Voice-KP	83
A9.2.2	The Real-Time Problem	84
A9.2.3	The New Word Problem	84

A9.2.4	The Synonym Problem	85
A9.2.5	The Verification Problem	85
A9.2.6	The User Modeling Problem	85
A9.2.7	General Semantics	86
A9.3	Sentence Level	89
A9.3.1	Review of the State of the Art	89
A9.3.2	Unsolved Problems at the Sentence Level	92
A9.3.3	Constraints Provided by the Sentence Level	92
A9.4	Lexical Level	93
A9.4.1	The Large Data Base Problem	93
A9.4.2	The Effect of Errorful Phoneme Strings	97
A9.4.3	Sources of Knowledge	97
A9.5	Phonemic Level	100
A9.5.1	The Lexical Segmentation Problem	100
A9.5.2	Errors in Phonemic Strings and the Multiple Labels Problem	103
A9.6	Parametric Level	110
A9.6.1	Parametric Variability Resulting from Segmental Context	110
A9.6.2	Parametric Variability Due to Syntactic and Semantic Context	111
A9.6.3	Parametric Variability Resulting From Speaker Characteristics	114
A9.7	The Acoustic Level	116
A9.7.1	The Noise Problem	116
A9.7.2	The Characteristics of the Transducer	116
A9.7.3	Signal Processing Techniques	117
A10.	A SIMULATION MODEL FOR PROJECTING THE PERFORMANCE OF SPEECH RECOGNITION SYSTEMS	118
A10.1	The Model	118
A10.2	Validation of the Model	121
A10.3	Conclusion	124
A11.	PHONEMIC ANALYSIS OF A FREE ENGLISH SENTENCE	125
A11.1	Glossary of Words Used in the Analysis	125
A12.	ALTERNATIVE MANAGEMENT SCHEMES	127
	BIBLIOGRAPHY	134