ROUTLEDGE

Reference

THE LINGUISTICS ENCYCLOPEDIA

EDITED BY
KIRSTEN MALMKJÆR

The LINGUISTICS ENCYCLOPEDIA

Edited by
Kirsten Malmkjær

North American Consultant Editor
James M. Anderson

ROUTLEDGE

LONDON and NEW YORK

First published in 1991
by Routledge
11 New Fetter Lane, London EC4P 4EE

Simultaneously published in the USA and Canada
by Routledge
a division of Routledge, Chapman and Hall, Inc.
29 West 35th Street, New York, NY 10001

Typeset in Great Britain by Megaron, Cardiff, Wales
Printed in Great Britain by Clays Ltd, St Ives plc

British Library Cataloguing in Publication Data
The Linguistics encyclopedia.
1. Linguistics
I. Malmkjær, Kirsten II. Anderson, James M. (James Maxwell) *1933–*
410.3

Library of Congress Cataloging-in-Publication Data
The Linguistics encyclopedia / edited by Kirsten Malmkjær; North American consultant editor, James M. Anderson.
p. cm.
Includes bibliographical references and index.
1. Linguistics—Dictionaries. I. Malmkjær, Kirsten. II. Anderson, James Maxwell, 1933– .
P29.L52 1991
410'.3—dc20 90–38466

ISBN 0–415–02942–2

Preface

You are reading something, or listening to a lecture, or taking part in a conversation about language. You notice an unfamiliar term or realize that you don't know enough about what is being said to understand. At this point, you should seek out this encyclopedia. Strategies for the use of encyclopedias differ, but this one is designed to allow you to proceed in one of three ways:

1 You can consult the Index where you will find the term or subject in question appearing in its alphabetically determined place, with a page reference, or several, which will tell you where in the main body of the work it is defined, described and/or discussed.
2 If you are looking for a major field of linguistic study, you can consult the Subject List where the entries and other major subjects are listed in alphabetical order.
3 You can simply dive into the body of the work.

The entries are designed to be informative and easy of access. They do not provide as much information as you will find in a full book on any given topic, but they contain sufficient information to enable you to understand the basics, and to decide whether you need more. They end by listing some suggestions for further reading. The entries draw on many more works than those listed as further reading. These are mentioned in the text by author and year of publication, and a full reference can be found in the Bibliography at the end of the book.

Since linguistics does not come neatly divided into completely autonomous areas, almost all the entries contain cross-references to other entries. In spite of their interconnectedness, entries are kept separate for reasons of speed of reference and because it is usually possible to draw a line between the areas with which they deal. There is a division of labour within linguistics as within all other disciplines, and within its subdisciplines. In some cases, this division has been so prolific that it is hardly possible to cover all the sub-areas in one entry. For example, sociolinguistics is now such a wide field that I thought it best to treat its sub-areas separately. Similarly, there are so many varieties of syntactic theory, that a single entry on 'grammar' or 'syntax' seemed more likely to confuse than enlighten. Other areas, such as historical linguistics and psycholinguistics still seem sufficiently unified to be manageable as one.

This volume demonstrates the many-faceted face of linguistics. Its history begins longer ago than we know, along with its very subject matter, and will continue for as long as that subject matter remains. Having language is probably concomitant with wondering about language, and so, if there is one thing that sets linguistics apart from other disciplines, it is the fact that its subject matter must be used in the description. There is no metalanguage for language that is not translatable into language, and a metalanguage is, in any case, also a language.

According to some, language is literally all that there is. According to others, it reflects, more or less adequately, what there is. What seems certain is that we use it prolifically in creating and changing our momentary values and that in seeking to understand language, we are seeking to understand the cornerstone of the human mentality.

Kirsten Malmkjær
Cambridge, 1991

Key to contributors

T.A.	Tsutomu Akamatsu	R.F.I.	Robert F. Ilson
J.M.A.	James M. Anderson	C.-W.K	Chin-W. Kim
J.B.	Jaques Bourquin	G.N.L.	Geoffrey N. Leech
D.C.B.	David C. Brazil	D.G.L.	David G. Lockwood
E.K.B.	E. Keith Brown	M.J.McC.	Michael J. McCarthy
T.D.-E.	Tony Dudley-Evans	M.M.	Molly Mack
S.E.	Susan Edwards	M.K.C.MacM	Michael K.C. MacMahon
E.F.-J.	Eli Fischer-Jørgensen	K.M.	Kirsten Malmkjær
W.A.F.	William A. Foley	M.Nk	Mark Newbrook
R.F.	Roger Fowler	F.J.N.	Frederick J. Newmeyer
A.F.	Anthony Fox	M.Nn	Margaret Newton
M.A.G.	Michael A. Garman	A.M.R.	Allan M. Ramsay
C.H.	Christopher Hookway	W.S-Y.W.	William S-Y. Wang

The contributors

Tsutomu Akamatsu studied Modern Languages at Tokyo University of Foreign Studies, Phonetics at the University of London, and General Linguistics at the University of Paris. He earned his Ph.D. from the University of Leeds, where he is a lecturer in the Department of Linguistics and Phonetics. He is a member of the Société Internationale de Linguistique Fonctionnelle (SILF). He has published around fifty articles in linguistics journals, and his book *The Theory of Neutralization and the Archiphoneme in Functional Phonology* was published in 1988.

James M. Anderson holds a first degree in Spanish and received his Ph.D. in Linguistics from the University of Washington, Seattle, USA, in 1963. He taught Linguistics at the University of Calgary, Alberta, Canada, from 1968 and became a tenured professor there in 1970. He was appointed Professor Emeritus on his retirement in 1988. In addition to some forty articles and papers, his publications include *Structural Aspect of Language Change* (1973) and *Ancient Languages of the Hispanic Peninsula* (1988). He co-edited *Readings in Romance Linguistics* (1972). He was President of the Rocky Mountain Linguistics Society in 1982.

Jaques Bourquin, Docteur ès sciences, Docteur ès lettres, is Professor of French Linguistics at the University of Franche-Comté, Besançon, France. He has written a thesis entitled 'La dérivation suffixale (théorie et enseignement) au XIX siècle', and several articles on the problem of reading, and on the epistemology of linguistics.

David C. Brazil was senior lecturer in English at the College of Further Education, Worcester, UK, from 1966 till 1975, when he became a Senior Research Fellow on the SSRC project 'Discourse Intonation' at the University of Birmingham, UK, led by Malcolm Coulthard. He received his Ph.D. from the University of Birmingham in 1978 and lectured there until his early retirement in 1986. Since then, he has been Visiting Professor at universities in Brazil and Japan. His main publications are *Discourse Intonation and Language Teaching* (1981), and *The Communicative Value of Intonation in English* (1985).

E. Keith Brown received his Ph.D. from the University of Edinburgh, UK, in 1972. He has lectured in Ghana and Edinburgh and has been Reader in Linguistics at the University of Essex, UK, since 1984. He has held visiting lectureships in Toronto, Stirling, and Cambridge, and his lecture tours have taken him to Germany, Poland, Bulgaria, Iran, and Japan. His major publications include (with J. E. Miller) *Syntax: A Linguistic Introduction to Sentence Structure* (1980) and *Syntax: Generative Grammar* (1982), and *Linguistics Today* (1984).

Tony Dudley-Evans is a lecturer in the English for Overseas Students Unit at the University of Birmingham, UK. He is co-editor of the *Nucleus* series and has co-authored a number of its volumes. *Writing Laboratory Reports* was published in 1985. He has written numerous articles on ESP-related themes; his current interests are Genre Analysis and its affiliation to the preparation of ESP materials, and Team Teaching.

Susan Edwards is a lecturer in the Department of Linguistic Science at the University of Reading and a qualified speech therapist.

Eli Fischer-Jørgensen was Professor of Phonetics at the University of Copenhagen from 1966 to 1981, and was appointed Professor Emeritus on her retirement. In addition to about seventy article publications on phonological problems, and several Danish language volumes, her publications include *Trends in Phonological Theory* (1975) and *25 Years' Phonological Comments* (1979). She was Chair of the Linguistics Circle of Copenhagen, 1968–72, and has served on the editorial boards of several journals devoted to Phonetics. In 1979 she presided over the ninth International Congress of the Phonetic Sciences, held in Copenhagen. She received honorary doctorates from the Universities of Åhus and Lund in 1978.

William A. Foley received his Ph.D. from the University of California, Berkeley. He taught for twelve years at the Australian National University, and now holds the Chair of Linguistics at the University of Sydney, Australia. He is especially interested in the languages of the islands of Melanesia, particularly the Papuan languages of New Guinea, about which he wrote a volume for the Cambridge University Press *Language Survey* series. His other interests include semantically and pragmatically based approaches to grammatical theory, and their application to the grammatical description of the languages of the Pacific.

Roger Fowler is Professor of English and Linguistics at the University of East Anglia, Norwich, UK. His numerous publications in the field of Critical Linguistics include *Literature as Social Discourse* (1981), *Linguistic Criticism* (1986) and, with R. Hodge, G. Kress and T. Trew, *Language and Control* (1979). Forthcoming books include *Language in the News*, a study of language and ideology in the British press.

Anthony Fox holds a Ph.D. from the University of Edinburgh. He is Senior Lecturer in the Department of Linguistics and Phonetics at the University of Leeds, UK. His research interests include Intonation and other suprasegmentals, Phonological Theory, and the linguistic study of German.

Michael A. Garman is a lecturer in the Department of Linguistic Science at the University of Reading, UK.

Christopher Hookway has been a Research Fellow of Peterhouse, Cambridge, UK. Since 1977 he has lectured in Philosophy at the University of Birmingham, UK. His publications include *Peirce*, (1985), and *Quine: Language, Experience and Reality*, (1988). He has edited *Minds, Machines and Evolution* (1984) and, with P. Pettit, *Action and Interpretation* (1978). His research interests are Epistemology, the Philosophy of Language, and American Philosophy.

Robert F. Ilson is an Honorary Research Fellow of University College London, UK, and Associate Director of the Survey of English Usage which is based there. He is Editor of the *International Journal of Lexicography* and the *Bulletin of the European Association for Lexicography*. He is Convenor of the Commission on Lexicography and Lexicology of the International Association for Applied Linguistics.

Chin-W. Kim received his Ph.D. in Linguistics from the University of California, Los Angeles, USA, in 1966. He is Professor of Linguistics, Speech and Hearing Sciences, and English as an International Language at the University of Illinois at Urbana-Champaign, USA. He contributed the entry 'Experimental Phonetics' in W.O. Dingwall (ed.) *Survey of Linguistic Science* (1978), and the entry 'Representation and derivation of tone' in D.L. Goyvaerts (ed.) *Phonology in the 80's* (1981). His fields of specialization are Phonetics, Phonology, and Korean Linguistics.

Geoffrey N. Leech is Professor of Linguistics and Modern English Language at the University of Lancaster, UK. He is co-author of *A Grammar of Contemporary English* and *A Comprehensive Grammar of the English Language*, both based on the Survey of English Usage based at University College London. He has also written books and articles in the areas of Stylistics, Semantics and Pragmatics, notably, *A Linguistic Guide to English Poetry* (1969), *Semantics: The Study of meaning* (2nd edn 1981), and *Principles of Pragmatics* (1983). In recent years, his research interests have focused on the computational analysis of English, using computer corpora: he began the LOB Corpus Project in 1970, and since 1983 has been co-director of UCREL.

David G. Lockwood received his Ph.D. from the University of Michigan (Ann Arbor), USA, in 1966. He has taught at Michigan State University since then, and has been a professor there since 1975. In addition to numerous articles, his publications include *Introduction to Stratificational Linguistics* (1972) and *Readings in Stratificational Linguistics* (1973), which he co-edited. His teaching specialities are Stratificational Grammar and Phonology, problem-oriented courses in Phonology, Morphology, Syntax and Historical Linguistics, Structure of Russian, and Comparative Slavic Linguistics.

Michael J. McCarthy is a lecturer in English Studies at the University of Nottingham, UK. He has published widely in the field of English Language Teaching, co-authoring *Vocabulary and Language Teaching* (1988). *Vocabulary* was published in 1990, and *Discourse Analysis for Language Teachers* is forthcoming. He holds a Ph.D. (Cantab.) in Spanish, and his current research interests are in ESP, Discourse Analysis, and Vocabulary.

Molly Mack received her Ph.D. in Linguistics from Brown University, USA. She is now an assistant professor in the Division of English as an International Language and in the Department of Linguistics at the University of Illinois at Urbana-Champaign, USA. Her research interests are in Speech Perception and Production, and the psycholinguistic and neurolinguistic aspects of Bilingualism. She also works as a consultant in Speech Research for the MIT Lincoln Laboratory, USA.

Michael K.C. MacMahon is a lecturer in the Department of English Language at the University of Glasgow, UK. He holds a Ph.D. on British neurolinguistics in the nineteenth century, and his publications have dealt with aspects of Phonetics, Dialectology and Neurolinguistics.

Kirsten Malmkjær was lecturer in Modern English Language and M.A. course tutor at the University of Birmingham, 1985–9, and is now a senior research associate in the Research Centre for English and Applied Linguistics, the University of Cambridge.

Mark Newbrook received his Ph.D. in Linguistics from the University of Reading, UK, in 1982. He has been lecturer in English Language at the National University of Singapore (1982–5), lecturer in Languages at the City Polytechnic of Hong Kong (1986–8), and lecturer in English at the Chinese University of Hong Kong from 1988. His leading publications include *Sociolinguistic Reflexes of Dialect Interference in West Wirral* (1986), *Aspects of the Syntax of Educated Singaporean English* (editor and main author) (1987), *Hong Kong English and Standard English: A Guide for Students and Teachers* (forthcoming).

Fredrick J. Newmeyer received a Ph.D. from the University of Illinois in 1969. He is a professor in the Department of Linguistics at the University of Washington, USA. He is Editor-in-Chief of *Linguistics: The Cambridge Survey*, and author of *English Aspectual Verbs* (1975), *Linguistic Theory in America* (1980), *Grammatical Theory: Its Limits and its Possibilities* (1983), and *Politics of Linguistics* (1986). His interests are Syntactic Theory and the History of Linguistics.

Margaret Newton holds the UK's first Ph.D. on Dyslexia. She is Director of the Aston House Consultancy and Dyslexia Trust in Worcester, UK, an independent charitable organization, which continues the clinical and research work in Dyslexia and the programme of dyslexia diagnosis, assessment and advice which Dr Newton and her colleagues began at the University of Aston in Birmingham, UK, in 1967. The team developed the diagnostic instruments known as the Aston Index and the Aston Portfolio of teaching techniques and prepared the Aston Videotapes on Dyslexia.

Allan M. Ramsay is a lecturer in Artificial Intelligence in the School of Cognitive Science at the University of Sussex, UK. He is co-author of *POP-11: A Practical Language for AI* (1985), *AI in Practice: Examples in POP-11* (1986), and *Formal Methods in AI* (forthcoming). His research interests include Syntactic Processing, Formal Semantics, Applications of Logic and AI Planning Theory to Language.

William S.-Y. Wang received his Ph.D. from the University of Michigan, USA, in 1960. Since 1966 he has been professor of Linguistics at the University of California at Berkeley, USA, and Director of the Project on Linguistic Analysis. Since 1973, he has been Editor of the *Journal of Chinese Linguistics*.

Acknowledgements

The great majority of the work involved in editing this encyclopedia took place in the School of English at the University of Birmingham. My colleagues there were a constant source of inspiration, support and encouragement. My debt to them is implicit in a number of entries in this work, but I want to make explicit my gratitude to the following one-time or present members of the ELR team: Mona Baker, David Brazil, Deirdre Burton, Malcolm Coulthard, Flo Davies, Tony Dudley-Evans, Harold Fish, Ann and Martin Hewings, Michael Hoey, Diane Houghton, Tim Johns, Chris Kennedy, Philip King, Murray Knowles, Paul Lennon, Mike McCarthy, Charles Owen, and John Sinclair.

My present colleagues, Gillian Brown, Richard Rossner and John Williams, have been no less supportive, and have helped me to discover new perspectives on a number of topics. I am particularly grateful to John Williams for his advice on the entries on Psycholinguistics and Language Acquisition.

A number of students at Birmingham have been exposed in one way or another to versions or drafts of some of the entries. I should like to thank them all for their patience and reactions; in particular, I am grateful to Martha Shiro and Amy Tsui for their helpful comments.

It goes without saying that I am very grateful indeed to the contributors themselves, all of whom had busy schedules, but who were, in spite of this, always ready to read and re-read their entries during the editing stage. I should particularly like to thank Tsutomu Akamatsu, who worked tirelessly and with great kindness to help me from the planning stage and throughout the editing process. Tsutomu Akamatsu, James Anderson, David Crystal, Janet Dean Fodor, Michael Garman, Tim Johns, Chin-W. Kim, George Lakoff, Bertil Malmberg, Maggie-Jo St John, Bertil Sonesson, Peter Trudgill and George Yule provided valuable guidance in the choice of contributors.

I am grateful to Nigel Vincent, Geoffrey Horrocks and Dick Hudson for their comments on the entry on Lexical-Functional Grammar, to Bernard Comrie for advice on the entries on Language Typology and Language Universals, and to the North American Consultant Editor, James Anderson, and the two anonymous readers, for taking on the enormous task of reading and commenting on all the entries. I hope they will all find the end result improved. Of course, the faults which remain are my sole responsibility.

This encyclopedia was the brain child of Wendy Morris of Routledge. Without her encouragement and guidance, I could not have contemplated taking on such a major commitment. I am grateful to her, to Steve, Poul and Stuart, who also believed the book would see the light one day, and to Jonathan Price of Routledge for his help in the later stages of editing.

David, Tomas and Amy have lived with this project through all our life together, providing the most delightful distractions and keeping everything in perspective. I could not wish for a better context.

K.M.

PERMISSIONS

The three versions of the International Phonetic Alphabet (pp. 220–2) are reproduced by kind permission of the International Phonetic Association.

In the entry on Acoustic phonetics, Figures 9 and 14 (p. 6 and p. 9) are reprinted with permission of the publishers from *A Course in Phonetics*, 2nd edn, by Peter Ladefoged, © 1982 Harcourt Brace Jovanovich, Inc.

Figure 10 in ACOUSTIC PHONETICS (p. 7) is reprinted with permission of the Journal of the Acoustical Society of America. Tables 1 and 2 in DISCOURSE AND CONVERSATIONAL ANALYSIS, and the quotations on pp. 101–5 are reprinted from J.M. Sinclair and R.M. Coulthard (1975), *Towards an Analysis of Discourse: The English Used by Teachers and Pupils*, by permission of Oxford University Press.

List of subjects

Bold typeface indicates an entry. Other subjects listed are covered in some detail within entries. For key words not included here, please refer to the Index.

Acoustic phonetics

Acoustic phonetics deals with the properties of sound as represented in variations of air pressure. A sound, whether its source is articulation of a word or an exploding cannon ball, disturbs the surrounding air molecules at equilibrium, much as a shove by a person in a crowded bus disturbs the standing passengers. The sensation of these air pressure variations as picked up by our hearing mechanisms and decoded in the brain constitutes what we call **sound** (see also AUDITORY PHONETICS). The question whether there was a sound when a tree fell in a jungle is therefore a moot one; there definitely were air-molecule variations generated by the fall of the tree, but unless there was an ear to register them, there was no sound.

The analogy between air molecules and bus passengers above is rather misleading, since the movements of the molecules are rapid and regular. Rapid in the sense that they **oscillate** at the rate of hundreds and thousands of times per second, and regular in the sense that the oscillation takes the form of a swing or a pendulum. That is, a disturbed air molecule oscillates much as a pushed pendulum swings back and forth.

Let us now compare air molecules to a pendulum. Due to gravity, a pushed pendulum will stop after travelling a certain distance, depending on the force of the push; will then begin to return to the original rest position, but instead of stopping at this position, will pass it to the opposite direction due to inertia; will stop after travelling about the same distance as the initial displacement; again will try to return to the initial rest position; but will again pass this point to the other direction, etc., until the original energy completely dissipates and the pendulum comes to a full stop.

Imagine now that attached at the end of the pendulum is a pencil and that a strip of paper in contact with the pencil is being pulled at a uniform speed. One can imagine that the pendulum will draw a wavy line on the paper, a line that is very regular in its ups and downs. If we disregard for the moment the effect of gravity, each **cycle**, one complete back and forth movement of the pendulum, would be exactly the same as the next cycle. Now if we plot the position of the pendulum, the distance of displacement from the original rest position, against time, then we will have Figure 1, in which the y-ordinate represents the distance of displacement and the x-abscissa the time, both units representing arbitrary units. Since a wave form such as the one given in Figure 1 is generatable with the sine function in trigonometry, it is called a **sine wave** or a **sinusoidal wave**. Such a wave can tell us several things:

First, the shorter the time of duration of a cycle, the greater (the more frequent) the number

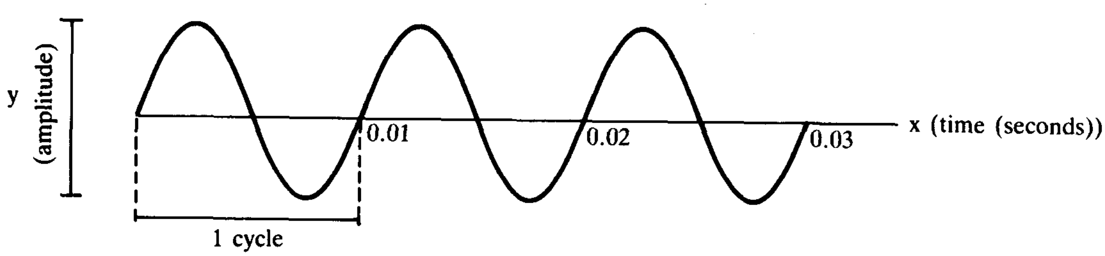

Figure 1 A sine wave whose cycle is one-hundredth of a second, thus having the frequency of 100 Hz

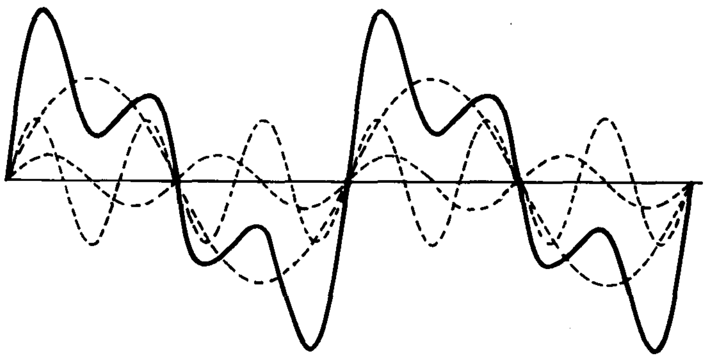

Figure 2 A complex wave formed with a combination of 100 Hz, 200 Hz, and 300 Hz component waves

of such cycles in a given unit of time. For example, a cycle having the duration of one hundredth of a second would have a frequency of 100 cycles per second (**cps**). This unit is now represented as **Hz** (named after a German physicist, Heinrich Hertz, 1857–94). A male speaking voice has on average 100–50 Hz, while a woman's voice is twice as high. The note A above the middle C is fixed at 440 Hz.

Secondly, since the y-axis represents the distance of displacement of a pendulum from the rest position, the higher the peak of the wave, the greater the displacement. This is called **amplitude**, and translates into the degree of loudness of a sound. The unit here is **dB** (decibel, in honour of Alexander Graham Bell, 1847–1922). A normal conversation has a value of of 50–60 dB, a whisper half this value, and rock music about twice the value (110–20 dB). However, since the dB scale is logarithmic, doubling a dB value represents sound intensity which is ten times greater.

In nature, sounds that generate the sinusoidal waves are not common. Well-designed tuning forks, whistles, sirens are some examples. Most sounds in nature have complex wave forms. This can be illustrated in the following way. Suppose that we add three waves together having the frequencies of 100 Hz, 200 Hz, and 300 Hz, with the amplitude of x, y, and z, respectively, as in Figure 2. What would be the resulting wave form? If we liken the situation to three people pushing a pendulum in the same direction, the first person pushing it with the force z at every beat, the second person with the force y at every second beat, and the third person with the force x at every third beat, then the position of the pendulum at any given moment would be equal to the displacement which is the sum of the forces x, y, and z. This is also what happens when the simultaneous wave forms having different frequencies and amplitudes are added together. In Figure 2, the dark unbroken line is the resulting complex wave.

Again, there are a few things to be noted here. First, note that the recurrence of the complex wave is at the same frequency as the highest common factor of the component frequencies, i.e. 100 Hz. This is called **fundamental frequency**. Note secondly that the frequencies of the component waves are whole-number multiples of the fundamental frequency. They are called **harmonics** or **overtones**. An **octave** is a relation between two harmonics whose frequencies are either twice or one-half of the other.

There is another way to represent the frequency and amplitude of the component waves, more succinct and legible than Figure 2, namely by transposing them into a graph as in Figure 3. Since the component waves are represented in terms of lines, a graph like Figure 3 is called **line spectrum**.

Recall that the frequencies of the component waves in Figure 2 are all whole-number multiples of the lowest frequency. What if the component waves do not have such a property, that is, what if the frequencies are closer to one another, say, 90 Hz, 100 Hz, and 110 Hz? The complex wave that these component waves generate is shown in Figure 4.

Compared to Figure 2, the amplitude of the complex wave of Figure 4 decays rapidly. This is called **damping**. It turns out that the more the number of component waves whose frequencies are close to one another, the more rapid the rate of damping. Try now to represent such a wave in a line spectrum, a wave whose component waves have frequencies, say 91 Hz, 92 Hz, 93 Hz, etc. to 110 Hz. We can do this as in Figure 5.

What if we add more component waves between any two lines in Figure 5, say ten or twenty more? Try as we might by sharpening our pencils, it would be impossible to draw in all the components. It would be unnecessary also if we take the 'roof' formed by the lines as the envelope of the amplitude under which there is a component wave at that frequency with that amplitude, as in Figure 6. To contrast with the line spectrum in Figure 3, the spectrum in Figure 6b is called **envelope spectrum** or simply **spectrum**.

What is the significance of the difference in the two kinds of spectra, Figure 3 and Figure 6b? It turns out that, if we divide sound into two kinds, *melody* and *noise*, melody has the quality of the forms, i.e. it has regular, recurrent wave forms, while noise has the latter quality, i.e. irregular non-recurrent wave forms.

Before turning to speech acoustics, it is worth noting that every object, when struck, vibrates at a certain 'built-in' frequency. This frequency, called **natural resonance frequency**, is dependent

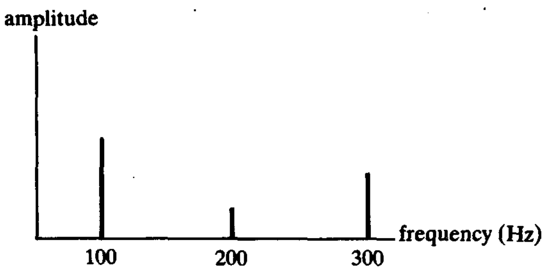

Figure 3 A line spectrum

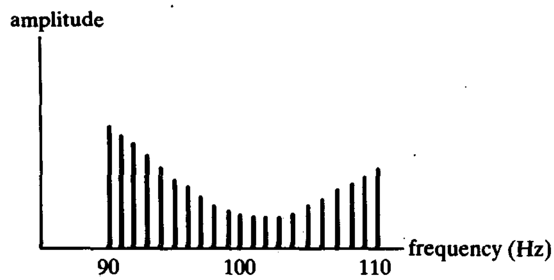

Figure 5 A line spectrum showing relative amplitudes and frequencies from 90, 91, 92 . . . to 110 Hz of the component waves

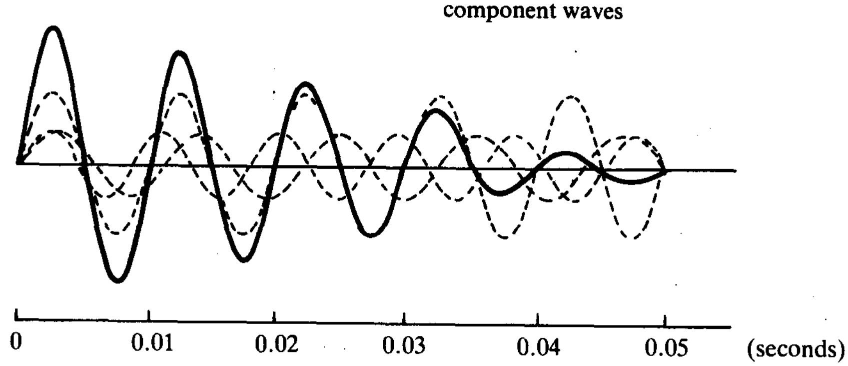

Figure 4 A 'decaying' complex wave formed with a combination of 90 Hz, 100 Hz, and 110 Hz component waves

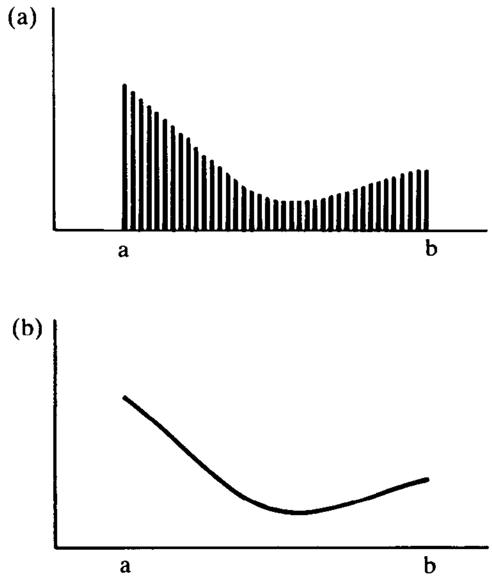

Figure 6 (a) A line spectrum with an infinite number of component waves whose frequencies range from a to b; (b) An envelope spectrum which is an equivalent of the line spectrum in Figure 6a

upon the object's size, density, material, etc. But in general, the larger the size, the lower the frequency (compare a tuba with a trumpet, a bass cello with a violin, or longer piano strings with shorter ones) and the more tense or compact the material, the higher the frequency (compare glass with carpet, and consider how one tunes a guitar or a violin).

ACOUSTICS OF SPEECH

VOWELS

A pair of vocal folds can be likened to a pair of hands or wood blocks clapping each other. As such, the sound it generates is, strictly speaking, a noise. This noise, however, is modified as it travels through the pharyngeal and oral (sometimes nasal) cavities, much as the sound generated by a vibrating reed in an oboe or a clarinet is modified. Thus what comes out of the mouth is not the same as the pure unmodified vocal tone. And to extend the analogy, just as the pitch of a wind instrument is regulated by changing the effective length or size of the resonating tube with various stops, the quality of sounds passing through the supraglottal cavities is regulated by changing the cavity sizes with such 'stops' as the tongue, the velum, and the lips. It is immediately obvious that one cannot articulate the vowels [i], [ɑ], and [u] without varying the size of the oral cavity (see also ARTICULATORY PHONETICS). What does this mean acoustically?

For the sake of illustration, let us assume that a tube consisting of the joined oral and pharyngeal cavities is a resonating acoustic tube, much like an organ pipe. The most uniform 'pipe' or tube one can assume is the one formed when producing the neutral vowel [ə] (see Figure 7). Without going into much detail, the natural resonance frequency of such a tube can be calculated with the following formula:

$$f = (2n - 1)\frac{v}{4l}$$

Where f = frequency, v = velocity of sound, and l = length of the vocal tract

Since v is 340 m per second, and l is 17 cm in an average male, f is about 500 Hz when $n = 1$, 1,500 Hz when $n = 2$, 2,500 Hz when $n = 3$, etc. What

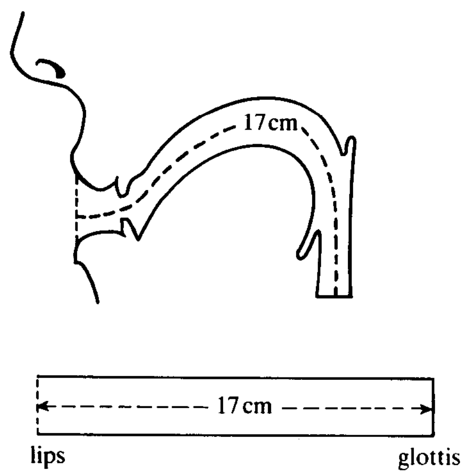

Figure 7 The vocal-tract shape and an idealized tube model of the tract for the most neutral vowel