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NON-SEGMENTAL PHONOLOGY IN LANGUAGE ACQUISITION: A REVIEW OF THE ISSUES [1]

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Research into children's language has been almost exclusively segmental and verbal, dealing (in the early part of this century) with such matters as form-class frequency and distribution, lexical development, sentence length and phonemic inventory, and (more recently) with the system of rules which needs to be specified to account for syntactic behaviour, and the definition of semantic relations which are postulated as underlying actual utterances. The nature and development of non-segmental phenomena in children is generally ignored or referred to haphazardly, as I shall be illustrating below; and the purpose of the present paper is therefore to argue that close account must be taken of these phenomena (particularly in relation to the study of language development in the first year), to discuss the work of those scholars who have recently begun to investigate this area, and to indicate directions for future research.

The term 'non-segmental' is being used here as a cover term for a wide range of linguistic features, most of which operate under more familiar labels. It subsumes such matters as intonation, stress, rhythm, speed of speaking, and the many effects which are loosely referred to as 'tone of voice'. Non-segmental phonology studies those sets of features of pronunciation which have an essentially variable relationship to the segmental/verbal aspects of an utterance, as opposed to those features – such as the vowels, the consonants, the syllabic structure – which have a direct and identifying relationship. One possible analysis of non-segmental phonology (described in detail in Crystal 1969, 1971) dis-

[1] This is a revised and expanded version of lectures first given to the 2nd International Congress of Applied Linguistics, held at Cambridge in September 1969, and then later to the 1st International Symposium on Child Language Acquisition, held at Florence in September 1972.

tinguishes some features as *prosodic*, if the basis of their auditory contrastivity is due to variations in pitch, loudness, duration, or silence, and others as *paralinguistic* (this term implying that the contrasts involved – such as nasalization or labialization – are phonetically less discrete than other phonological features, and do not integrate so readily with the remainder of the linguistic system). This model has been applied largely to the description of adult pronunciation, though an initial attempt to study children's language in these terms may be found in Crystal 1970).

It is not difficult to see why so little attention has been paid to this area within language acquisition studies – the reasons are largely the same as those underlying the neglect of prosodic and paralinguistic study of adult language. There is the difficulty of obtaining natural and reliable samples of speech for analysis, and of relating non-segmental characteristics to other (and even less-studied) communication modalities, such as the visual and tactile – a particular problem for the study of young children, where kinesic and other cues regularly need to be taken into account for any complete interpretation of non-segmental patterns. There is the absence of a generally agreed system of classification and transcription of the whole range of non-segmental contrasts: if we have had to wait until the sixties for any remotely adequate attempts at characterizing the adult terminal behaviour involved (I exclude Pike's (1944) study from this statement, which is quite exceptional for the detail of its suggestions), then it is hardly surprising that in the last decade, little application of these descriptions to children has been forthcoming; and next to no attempt has been made to carry out independent studies of children to avoid the danger of imposing too much adult non-segmental structure on early utterances (e.g. talking about a 10-month-old in terms of four phonemic pitch-levels). Also, there is the problem of the disproportionate amount of time it takes to process non-segmental data – checking transcriptions, carrying out acoustic analyses, and so on – which severely limits the practicability of reliable longitudinal and cross-cultural studies.

There are signs, however, as the size of the bibliography attached to this paper indicates, that there is a growing interest on the part of many disciplines in the various aspects and implications of non-segmental studies. Most of the recent papers are to be found in journals of linguistics, social or developmental psychology, audiology, pediatrics and speech pathology. But multi-disciplinary interest in an area brings with

it a host of methodological and theoretical problems, not the least of which is difficulty over terminology, and any review of the subject must begin with these, as a perspective for clear thinking.

Various terminological discrepancies emerge. One inconsistency (which may be dealt with briefly) arises in relation to the general labels used for the early stages of child development – 'neonate', 'infant', 'baby', and so on. Definitions are almost entirely absent from the early literature, or use bizarre criteria (e.g. infancy as the period of childhood preceding erect posture, or the frequently cited 'etymological' definition, where 'infant' was considered to be, literally, a child 'without speech'). In recent work, a phrase such as 'infant vocalization' is sometimes used to exclude 'neonate vocalization'; sometimes it includes it; sometimes the term 'neonate' is not used at all, or is replaced by such phrases as 'the young infant'; and so on. In this paper, *neonate* refers to a child up to and including its fourth week of life after birth; *infant* refers to a child up to and including its 104th week. One may thus talk of the neonatal period of infancy, etc.

Secondly, there are a large number of labels used to refer to the utterance of the child at any time within this period (or later) – 'cry', 'vocalization', 'utterance', 'verbal gesture', 'non-verbal articulation', 'expressive noise', 'oral behaviour', 'phonation', etc. Terms from this range are hardly ever defined, and, as far as I can judge, are only occasionally used in the same way by different authors, one of the main problems being that the same label may be given a different value at different periods of development. The first two terms just listed provide the best examples of potential ambiguity. 'Cry' is regularly used to refer to *any* vocal sound pattern produced by an infant over the first few weeks of life; but some researchers state or imply a more restricted definition. For example, Blanton (1917) considers crying primarily in terms of vowel quality; for Lynip (1951: 245), the 'elements' of crying are 'intonation, cadence, rhythm, attack, duration'; Ostwald (1963: 40) requires cry to have 'tonal quality', as distinct from the 'rasp' which characterizes 'scream'. Eisenson et al. (1963) make a distinction between undifferentiated (reflex) crying, up to 2 mth, differentiated crying, where there is some evidence for specific response patterns, and the subsequent stages of babbling, lallation, and echolalia, from whose definition crying is specifically excluded. A cry signal, for Wasz-Höckert et al. (see, e.g. 1968: 9) consists of 'the total vocalization occurring during a single expiration or inspiration'. Crying as a label is not used at all by

some authors, e.g. Jespersen (1922), who talks instead of 'screaming'. The term 'vocalization', similarly, is sometimes defined in an all-inclusive way, to include all patterns of sound produced by a child within a period of study; but it is sometimes narrowed in application, for example to mean a short series of cry signals indicative of a given function (Wasz-Höckert et al. 1968); to mean simply babbling (Dittrichová and Lapáčková 1964); to exclude grunts, cooing and singing tone (McCarthy 1946: 482–3); to include the later non-cry sounds of lalling, gurgling, laughing, etc. (Wolff 1969), or to exclude them (Wasz-Höckert et al. 1963); to refer to segmental features only, or to non-segmental features only, or to some combination, or to some subset of either (e.g. Ostwald (1963) restricts vocalization to sounds made when the mouth is wide, i.e. excluding lallation and babbling in his terms); to subsume both prelinguistic and linguistic utterances, or to include the former only; and so on. One could illustrate similarly from other widely used labels: 'nonverbal' sometimes means non-vocal, sometimes non-segmental, and sometimes a specific non-segmental parameter (e.g. 'tonal' in Brooks et al. 1969); the 'sounds' of infant vocalization are sometimes viewed as segmental (e.g. Irwin 1941; Irwin and Chen 1943), sometimes non-segmental.

'Intonation' is another term about which there is considerable disagreement, and which, consequently, needs to be carefully watched. It is normally defined by reference to some form of pitch contrastivity alone, but other kinds of prominence are sometimes permitted under this heading, e.g. the concepts of 'accent' and 'rhythm', which require reference to loudness and duration. Tonkova-Yampolskaya (1968) uses the term to refer to the general characteristics of vocalizations; and in discussion of whispered speech in children, the term 'intonation' is sometimes used, though here the articulatory correlates are primarily pharyngeal (cf. Trim 1969). A good example of confusion arising from inconsistent definition is in the debate over Braine's theory of contextual generalization (1963; see 1967: 248). Here, intonation is 'defined' as 'the variety of phenomena referred to by such terms as stress, pitch, juncture, off-glide, on-glide, contour, superfix, intonation-pattern'. It is also 'certain specifiable properties of the speech signal', and sometimes stress is distinguished (e.g. primary stress is isolated in his fifth experiment, cf. also p. 278n.). In their reply, however, Bever et al. (1965; see 1967: 270) talk about 'pause, stress and intonation' – which makes one wonder exactly what phenomena are being discussed at all. Moreover,

to define intonation in terms of pitch does not necessarily end the question, as the term 'pitch' itself has of course been taken in a number of ways, e.g. referring to fundamental frequency, to the auditory correlate of fundamental frequency, to the auditory correlate of not only fundamental frequency but also other dimensions of the speech signal (e.g. amplitude, length), and even to something separate from intonation (cf. Lewis 1936: 15), who talks of 'sounds, intonation and pitch', or Fitchen's distinction between intonation and 'tone' (1931: 325)). And Brown (1958: 202–3) implies that intonation is not a 'phonetic feature' at all. A similar range of viewpoints could be collected for many of the other central descriptive terms in this field.

In this paper, I shall be using the term *vocalization* to refer to *any* vocal sound pattern produced by an infant for which there is no evidence of language-specific contrastivity, i.e. the sound patterns are biologically controlled. This thus subsumes cries, cooing and other such 'pre-linguistic' phenomena, in both their segmental and non-segmental aspects. As soon as there is evidence of phonological contrastivity, segmental phonation becomes describable in terms of phonemes, distinctive features, vowels, consonants, etc.; and non-segmental phonation in terms of prosodic features, intonation, paralinguistic features, etc. There will inevitably be occasions when it is not possible to decide clearly on the status of a sound pattern; but this of course does not invalidate the distinction. Whenever the term *intonation* is used by me in this paper, it refers to a system of non-segmental linguistic contrastivity which varies primarily in terms of pitch-direction and pitch-range; variations in loudness, duration and rhythm which may sometimes enter into the definition of intonational units, but in a secondary role, are viewed as comprising separate (prosodic) systems. It follows from these definitions, then, that one may not consistently talk about the 'intonation of vocalizations', for this would be to use a linguistic term in a non-linguistic domain. Some alternative term (e.g. 'melody') would have to be used to refer to the auditory correlate of fundamental frequency variation in vocalization.

A crucial area of terminological difficulty in this field concerns the functional labels used in describing infant vocalization and the developing non-segmental system. Labels such as 'hunger', 'pain', 'pleasure', and the like for vocalizations are all perfectly familiar, and almost all investigators use them. But there are dangers in their uncritical use, as has been shown in connection with adult work (Kramer 1963; Crystal

1969: ch. 7). On the one hand, the type of descriptive label used is generally ambiguous; on the other, the interpretation which is the basis of the label need not be based on the vocalization characteristics at all. The first point may be illustrated by such terms as 'harsh', 'rasp', 'scream' and 'rhythmic', which are extremely difficult to define in any precise way; and of course terms with a strong psychological element, such as 'satisfied' or 'exhausted', are even more so. The same would apply to terms used to describe adults' responses to vocalizations (cf. Ostwald 1963). The early literature in particular makes frequent use of undefined 'imitation-labels', where the absence of controls makes it impossible to determine whether terms such as 'satisfied' are being used consistently by authors, whether there is any overlap between 'satisfied' and 'pleased', and so on (cf. Shirley 1933). More recently, there is Barnard et al.'s (1961) study of anxiety and verbal behaviour, where one of their 'stylistic dimensions' of description is called *voice*, for which there are three variables: 'degree of animation', comprising a 50-point scale from 'complete animation' to 'complete monotone'; 'direction of animation', comprising a 40-point scale from 'strongly positive' (i.e. 'happy', 'cheerful', 'excited' voices) to 'strongly negative' (i.e. 'sad', 'frightened', 'depressed' voices); and 'forcefulness', comprising a 30-point scale from 'forceful and persuasive' through 'undistinguished' to 'mousy'. Here, too, careful controls on the labels used are needed to render the methodology of the experiment sound.

In the majority of studies, also, it was the case that investigators believed they were identifying vocalization-types on the basis of the physical characteristics of the vocalizations, wheras in fact they were doing this on the basis of the co-occurring situational information and reading in adult situational values. This point applies a fortiori to the semantic description of the intonation patterns of the early years. McCarthy (1929) is aware of the problem, and Sherman (1927) has provided some evidence bearing on the issue. In this very detailed study, it was shown that judges were unable to identify vocalization types (hunger, fear, anger, pain) when the situational stimulus which gave rise to them was hidden from the judges, and concluded that knowledge of the stimulus is the deciding factor in applying a name to a vocalization-type. To be convincing, of course, this experiment needs an independent assessment of the labels used, to determine, for instance, whether the semantic generality of a label would cause it to be preferred to other labels as a matter of course, or whether individual

judges had preferences for certain labels. Wasz-Höckert et al. (1964a,b), for example, found that when response categories were provided in advance in a multiple choice test (and not thought up by the judges) the degree of success in identifying the various vocalizations investigated (birth, hunger, pain, pleasure) did have some correlation with the experience of the persons tested – the more experienced the judges in child-contact, the better the identification. Partanen et al. (1967) showed that experienced adults could discriminate three out of four cries produced by various pathological and normal children, the discrimination ability of the judges improving with practice. (See also Michelsson et al. 1965; Valanne et al. 1967).

Determining the causes of a vocalization, as Wolff makes very clear, is an extremely complex task. One cannot assume that in any given situation what the adult sees as the obvious causative factor is in fact the real cause. This is particularly evident in the case of the so-called 'hunger cry' (cf. Wolff 1969: 82): 'The term is misleading if it implies a casual relation between hunger and a particular pattern of crying, since this is simply a "basic" pattern to which the infant sooner or later reverts from other crying, and it has no unique causal relation to hunger'. A pain cry, for example, begins distinctively, but after a while it takes on the characteristics of the basic pattern – in other words, while in one sense a pain cry is a response to a pain stimulus, it is not the case that the characteristics of the cry are constant throughout. The tendency to read in meanings into infant vocalizations is common and unfortunate, particularly in the early reports on the subject; and while much less work has been done on the developing intonation system than on vocalizations, it is clear that there has been little attempt to impose careful controls on semantic labels here either. This is even more disturbing, in view of the fact that as intonation contours do not have single 'meanings', but can be used in a variety of semantic contexts, the likelihood of misleading labelling is correspondingly much increased.

Underlying much of the terminological confusion, then, is a lack of attention to the demands of an explicit methodology, and also an inadequate discussion of theoretical preliminaries. The term 'non-segmental' itself provides a good example. While there has been considerable discussion of the theoretical status of non-segmental (or 'supra-segmental') features in linguistics (the arguments are summarized in Crystal, forthcoming), it is not common to see awareness of the issues

in the preamble to research reports investigating non-segmental phenomena in children. Are non-segmental features clearly linguistic (in the same sense as phonemes are said to be), marginally linguistic, or non-linguistic? Are all non-segmental contrasts of comparable status, or do some features carry a greater contrastivity than others? To what extent can intonation be seen as a single system, and isolated from other prosodic features? Can the categories and results of linguistic models set up to account for adult language be used for children? There are many such questions, and many possible positions that can be taken up. A good example of this is the first question, as applied to the concept of intonation. The early handbooks and articles (e.g. Darwin 1877), whenever they talk of intonation, seem to mean no more than the general melodic impression obtained from listening to infant cries, though sometimes only those patterns which are clearly affective are meant. Most recent approaches give intonation a clearly linguistic status, i.e. seeing it as a component of a specific language-system, and thus to be kept distinct from vocalizations; but some linguists use the term with both a linguistic and a 'pre-linguistic' reference, e.g. Lieberman (1967: 46): 'At some point in the development of speech, intonation takes on a linguistic reference'. And depending on the theoretical position adopted, so a particular pitch pattern in a child's utterance will be analyzed as linguistic by some, and as non- or extra-linguistic by others. Anyone who approached the study of early language development within a Trager–Smith framework, for instance, would find that he would have to call much of the semantic contrastivity which appears towards the end of the first year non-linguistic (e.g. some of the variations in rhythm and pitch-range which contribute to the child's 'tones of voice'). This is because 'linguistics proper' (see Trager 1964:23) is defined as being essentially phonemics and morphemics, and any contrastivity which defies rigid phonemicization is excluded. Detailed arguments against this position have been given elsewhere (e.g. Bolinger 1949; Crystal 1969, forthcoming); and there have developed alternative approaches which deny the relevance of the phoneme concept to intonation, arguing instead for a description in terms of different degrees of linguistic contrastivity within intonation – here, two pitch patterns might both be granted linguistic status, but one might be viewed as having a more central linguistic role to play than the other. Clearly, unless one is aware of the criteria which have been used in arriving at a description, comparative study becomes impossible, and quantitative analysis largely meaningless.

Any division of this field into areas of study is inevitably arbitrary, but it is convenient to recognize three main groupings: (1) early, 'pre-scientific' investigations, largely on the first year of life; (2) recent parametric analysis of vocalizations in young infants; (3) studies of non-segmental patterning in older children, especially in relation to syntax and social role. I shall briefly review each of these groupings before concluding with some comments about the direction of future research.

1. Early research

A survey of the early literature on language acquisition is still very much needed. There seems to be very little reference made to infant vocalization, apart from general remarks in the standard textbooks of child psychology, and a few impressionistic comments about vowel types and affective categories; and what there is is on the whole methodologically unsatisfactory. The early biographical accounts, for instance (e.g. Taine 1876; Darwin 1877; Humphreys 1880; Champneys 1881; Hall 1891; Lukens 1896; Shinn 1900; Schäfer 1922; Hoyer and Hoyer 1924; Löwenfeld 1927; see the surveys in McCarthy 1929; Lewis 1936; and the selection in Bar-Adon and Leopold 1971), always make some mention of vocalization, and provide some suggestion of a developmental pattern, and the level is certainly more sophisticated than the passing remarks of the philisophers in the centuries preceding,[1] but the material is more valuable for its stimulus to the study of verbal and grammatical patterns. So while acknowledging the pioneer status of these scholars, it is only right to say that the occasional insight is generally obscured by the unsystematic and scattered observations, the absence of anything which could be called a methodology, the vague descriptions, and the flights of fancy. For example, Taine (1876: 253), after commenting on the surprising flexibility of the child's 'twitter', says: 'I am persuaded that all the shades of emotion, wonder, joy, wilfulness and sadness are expressed by differences of tone: in this she equals or even surpasses a grown up person. If I compare her to animals,

[1] For example, Kant's comment that 'the outcry that is heard from a child scarcely born has not the note of lamentation but aroused wrath'! This kind of comment was given short shrift by Tracy (1909: 128).

even to those most gifted in this respect (dog, parrot, singing-birds), I find that with a less extended gamut of sounds she far surpasses them in the delicacy and abundance of her expressive intonations'. Then there is Blanton's (1917) 'barnyard' theory of cries (as Irwin once put it (in his 1941 paper)), comparing infant vocalizations with those of quails, goats, pigs and wild cats, amongst others. And, as a third example, there is the theorising of Darwin (1877: 293): 'before man used articulate language, he uttered notes in a true musical scale as does the anthropoid ape Hylobates'. (Cf. also Blanton's description of a colic cry in terms of a musical scale (1917: 458–9), and Fitchen (1931: 325).)

There is more description of a functional nature, but it is extremely vague, e.g. Darwin (1877: 293) mentions interrogatory and exclamatory cries, and a 'defiant whine of refusal'; Champneys (1881) is impressed by the variability of infants' vocalization, and cites three functional differences, which he labels loneliness and fright on awakening, hunger and pain. Blanton (1917: 458) distinguishes between cries due to hunger, noxious stimuli and fatigue, and gives a fairly detailed impressionistic description of the 'rhythm' of hunger cries. The occasional theoretical digression is usually obscure, important terms not being explicitly defined, e.g. Darwin (1877: 293): 'I remark in my notes that the use of these intonations seem to have arisen instinctively, and I regret that more observations were not made on this subject . . . the wants of an infant are at first made intelligible by instinctive cries, which after a time are modified in part unconsciously, and in part, as I believe, voluntarily as a means of communication, – by the unconscious expression of the features – by gestures and in a marked manner by different intonations...'. The desirable emphasis of these remarks unfortunately does not help our understanding of them. Finally in this connection, it must be pointed out that much of the discussion of articulation at this early period was in the context of correcting errors of pronunciation (see Pike 1944; Crystal 1969: ch. 2, for references to elocutionary manuals, etc.).

Overlapping with this early period of biographically orientated investigation, there are the larger surveys of language development: Blanton (1917) in many respects anticipates the approach of Bridges (1932), Shirley (1933) and others – see McCarthy (1929) for a good review of this early literature, and also Lynip (1951: 249ff.), Lewis (1936), McCarthy (1946), Ingram (1971) and Weir (1966), the latter for some work in Czech. Bridges, for example, provides a much fuller account of

progressive differentiation of affect than hitherto: out of an initial state of 'excitement' there develops a distinction between delight, distress and excitement by three months; distress divides into fear, disgust and anger by six months; elation and affection are added to delight by twelve months; jealousy, and a distinction between affection for adults and affection for other children are added by eighteen months; and joy appears around twenty-four months. The totally personal, partial, over-simple and impressionistic nature of this account is clearly indicated when one compares the claims of other surveys of functional development: cf., for example, Lewis's review of various accounts (1936), or McCarthy's survey (1946: 482–3), where it emerges that discomfort, pain and hunger are said to be differentiated by two months; pleasure develops in the four months following; eagerness at about five months; satisfaction between six and seven months; and recognition between seven and eight months. Many of the criticisms which can be levelled at this kind of work were made fairly early on by Irwin (1941: 248), who pointed to the poor sampling and very restricted data, the unsystematic research methods, the general absence of statistical techniques, the lack of observer reliability tests, the poor, alphabetic system of transcription, and the premature interpretation of few observations. I would add to this the uncritical use of semantic labels, already noted.[2]

In many ways the major difficulty in interpreting the work of this early period (and indeed of much recent work too) is the extent to which the linguistic events are automatically categorized in terms originally defined for the study of the adult language. Now while an adult-orientated approach is probably unavoidable in dealing with the semantic labelling of contrasts, there being no direct method of encountering children's intuitions at this early stage (cf. McNeill 1966: 17–18; Wasz-Höckert et al. 1968: 4), it is highly undesirable to allow adult considerations to interfere at the phonological level of analysis and transcription. As far as possible, the child's utterance has to be described 'in its own terms', as some would say. The point has been appreciated for some time in the context of segmental phonology; but the atti-

[2] There are of course exceptions. As early as 1906, attempts were being made using sound recording to establish mean neonatal crying pitch (Flatau and Gutzman 1906). And then there is the systematic approach of Bühler (e.g. 1922: 79ff.), who places great emphasis on the 'musical devices of syntax' in the early development of language – the use of intonation to distinguish sentence-types and emotional ranges of expression – and insists on its theoretical relevance for syntactic analysis.

tude of Lynip (1951: 226) is quite exceptional in non-segmental studies:

'It is totally impractical to try and express in adult sounds an utterance of an infant prior to his speech maturation . Infant utterances are not *like* any of the well defined values of adult language. They are produced differently and they are shaped differently, their relationships with adult sounds are at first only fortuitous. Infant sounds cannot be described except in terms of themselves. There is no International Phonetic Alphabet for the utterances of a baby'.

What Lynip was objecting to was the general practice of referring to infant vocalizations in terms of the vowels and consonants of adult speech. Irwin and others had earlier on objected to the habit of using ordinary orthography to transcribe vowel values, etc.; but they failed to realize that the substitution of a phonetic alphabet developed originally to transcribe the broad phonetic categories of adult languages did not get round the basic fallacy (see, for example, Irwin and Curry (1941), who analyze the 'vowel' sounds in infant to show that [ɪ ɛ æ] and [ʌ] are the most frequent units; or Irwin (1941), who talks in terms of 'phonemes').

The adult-based procedure is fallacious for two main reasons. First, it has been shown that any such analyses are inevitably skewed due to the influence of the phonological structure of the adult language, which leads one to interpret sound qualities in terms of the adult set of distinctive features, and to ignore qualities which are functionally irrelevant in the adult language (see, e.g. Lotz et al. 1960). Second, while perceptual units of infant vocalization approximate to certain adult units in some cases, the physical configuration underlying these units is by no means similar. This point has become perfectly clear since the advent of spectrographic analysis. Even the spectrograms of an adult trying his hardest to imitate an infant show major differences (see Lynip 1951; Wolff 1969: 104, for examples; and cf. Denes 1966: 338). The formant structure is different, the nature of the onset and termination of a sound is different, the transitional features between sounds differ, and so on. Lynip suggests that even approximate equivalence to adult vowels or consonants is not achieved until the end of the first year. The general point is made again by Lenneberg (1967) who, after considering spectrographic characteristics, points out that one cannot call these features 'speech sounds', neither in functional terms nor in articulatory/acoustic terms: degrees of glottalization and labialization occur which are normally absent from adult articulations, and there is a generally erratic articulation and poor coordination between the various

mechanisms. A more adult-like distribution of energy does not appear until the onset of 'cooing'. See McCarthy (1946: 478) and Sheppard and Lane (1968: 94–5) for further comment, and below for details of the physical characteristics of vocalization. Cinefluorographic and other techniques likewise show considerable differences (see Bosma and Fletcher 1961). Of course it may well be that non-segmental infant patterns do show a greater similarity to adult patterns than the above spectrographic analyses suggest for segmental features. Spectrograms after all do not generally display non-segmental features as clearly as segmental ones, particularly when high fundamentals are involved. Tonkova-Yampolskaya (1968) in fact argues that there is substantial similarity between adult and early child intonations. But until there is clear evidence on the point, the wisest course of action would seem to be to develop a frame of physical reference-qualities for auditory labels in child phonetics which is as independent as possible of those used in adult classificatory systems. If this is not done, the danger is that one may find oneself studying 'pseudo-continuities' between developmental stages, i.e. continuities which are solely a function of surface similarities in the transcriptional system, and which have no basis in the physical facts of utterance.

Apart from this, the early literature talks a great deal about the development of response to adult intonation contours, though unfortunately very little information about the adult intonations used is given. For example, Schäfer (1922) states that intonation plays a large part in determining the child's response to given sound-groups, and notes that the response is facilitated whenever an exaggerated intonation ('Ammenton') is used; also that in the earlier period, the child pays more attention to non-segmental than segmental patterns. Champneys (1881: 106) notes that his child was imitating intonation from about nine months: it 'distinctly imitated the intonation of the voice when any word or sentence was repeated in the same way several times'. (Cf. also Darwin 1877.) Further evidence for the response of children to intonation is provided by Tappolet's (1907) informal experiment, in which he switched from French to German while retaining the same intonation, without this affecting the child's response. See also Delacroix (1934), Meumann (1903), Hoyer and Hoyer (1924), Löwenfeld (1927), Guillaume (1925), Stern and Stern (1928), Bühler (1930), and Bühler and Hetzer (1928) for general agreement that early discrimination of intonation is of major importance in language acquisition, and a

few details of an empirical nature. Bühler (1930) claims that the average child reacts to a change in adult tone of voice by as early as two months, and most authors cite somewhere between two and four months.

Lewis (1936) reviews most of the early literature in this respect, and refers to intonation frequently throughout his book. The effect of an intonation pattern for him may be expressive or repesentational (pp. 115–16), the former being 'expressive of the speaker's affective state' (p. 115), or, more precisely, contributing to the differentiation of expressive states (p. 23); the latter occurring when the intonation 'pictures the situation', as a 'kind of onomatopoeia', as when 'tick-tack' is spoken in time with a clock (p. 115). It is important to study intonational function, he argues, as it continues its role beyond the stage of the first word (p. 203): 'the closer imitation of intonational patterns fosters ... the instrumental use of conventional language' (p. 95). He provides his own general analysis of the situation, distinguishing three stages in the development of a child's response to a specific sound-group (pp. 115–16):

> '(1) At an early stage, the child shows discrimination, in a broad way, between different patterns of expression in intonation.
>
> (2) When the total pattern – the phonetic form together with intonational form – is made effective by training, at first the intonational rather than the phonetic form dominates the child's response.
>
> (3) Then the phonetic pattern becomes the dominant feature in evoking the specific response; but while the function of the intonational pattern may be considerably subordinated, it certainly does not vanish'.

Lewis reports many cases of intonation being imitated (in terms of number of syllables and stress as well as pitch) by seven months (pp. 94–5), and makes the point that one must distinguish between the imitation of pitch *per se* and the imitation of a pitch pattern. He considers the former rare before two years (though cf. Wolff below, and Lewis himself reports a case of a series of tones being imitated before the end of the first year), the latter beginning around eight months. More recently, Benda (1968) has found an ability to imitate intonation in the babbling of an eight-month-old girl, there being a regular correlation between the intonation and the behavioural situation. Lieberman (1967: 44–6) shows that a child's absolute fundamental frequency range varies in terms of the relative height of the voice of the parent. Wolff (1969: 104–5) states that a baby will tend to follow adult pitch

to a certain extent as early as between one and two months, but points out that this is not so much 'imitation' in his view as 'an active "accommodation" of vocal patterns which are already at the infant's disposal' (p. 105), though it is not entirely clear what 'accommodation' refers to here. Cf. further, Fry (1966: 188), Friedlander (1968), and the references to earlier literature in Ingram (1971), especially to Lukens (1896). Kaplan and Kaplan (1970) have produced a useful summary of stages of perceptual development relating to infant vocal behaviour, as part of a general hypothesis arguing for the continuity of linguistic development in children.

It is not clear to what extent one can rely on the observations of the early work: scholars on the whole seem to underestimate the difficulty of perception and complexity of intonational patterns, and much of the terminology of description (talk of 'melody', 'descending patterns', etc.) is vague. The main weakness in this work which makes it almost impossible to use for points of detail, however, is the absence of precise information about the characteristics of the adult intonational stimulus. The nature of the 'baby-talk' is obviously an important factor in assessing response, and has to be controlled; but hardly anyone provides an account of it in this literature. Because baby-talk is so distinctive, I feel many scholars have assumed it need not be described. But the scattered evidence available suggests that it is a much more complex phonemenon than people expect, and that different languages have different kinds of baby-talk. I have come across two specific studies. Ferguson (1964) investigates baby-talk in a number of languages: with reference to English, he cites the higher overall pitch, the preference for certain pitch-contours, and labialization. Kelkar (1964), under the heading of 'paraphonology', refers to the extended pitch loudness characteristics, and the relatively slow and regular speed of baby-talk in Marathi, and mentions certain general vocal effects, such as pouting and palatalisation; Ohnesorg (cited in Weir 1966) points to the overarticulation of intonation when adults speak to children, which he says the child tends to caricature. Ohnesorg also notes a frequency of rising tones in children's early intonation, which is presumably a reflection of the kind of adult speech used. This point was also noticed by Pike (1949), who was able to train a child to replace these by falling tones for a time.

It is thus quite clear that adult intonation patterns tend to be 'picked up' (to use a neutral phrase) by the child from an extremely early age, and responded to at the expense of other linguistic features of utter-

ance. What is now needed is an investigation of the characteristics of adult prosodic features when talking to children. It seems essential that the adult patterns should be understood, and controlled in experimental work. On the whole, however, most of the research into development at this early period fails to take any notice of non-segmental patterns at all. If an attempt is being made to elicit a response from a baby – say, reaching – I have often noticed the investigator keeping up a relatively uncontrolled flow of chatter to the baby, with frequent baby-talk, even though this could disturb the results considerably. At least the possibility of disturbance needs to be determined, and the extent to which auditory stimulation can interfere with, say, a visual experiment, tested. Braine (1963: 245) is one who is aware of the dangers of uncontrolled non-segmental patterns; in the course of his fifth experiment, for older children, he states that 'the experimenter was careful not to give voice or gestural cues which would guide the subject to the correct response'. Here I would have liked more detail as to how this was done; but the emphasis is nonetheless welcome.

2. Recent analysis of vocalization

From the early studies, then, it was clear that non-segmental patterning in general, and intonation in particular, seemed to be the earliest kind of linguistic structuring in the vocalization of the child, but there was little reliable normative information, and descriptive statements stayed couched in fairly general and impressionistic terms. This state of affairs, sadly, has shown little improvement in recent work, which on the whole has concentrated on determining the onset of language-specific patterning in vocalization, the 'where does language start?' question. Most observers have concluded that the most likely period for the emergence of such features in production is 6–7 mth (see, for example, Crystal 1970; Fry 1966: 191; Kaplan and Kaplan 1970; Lenneberg 1967: 279; Menyuk 1971: 56ff.; Weir 1966, and other references there). There is some suggestion of an earlier emergence in some children (e.g. Raffler Engel 1966, 1970, who posited two 'intonemes' at four months in her child, one being used for desiderative and one for deictic purposes); and Nakazima's (1966) spectrographic comparison of American and Japanese infants produced no detectable difference until as late as twelve months. So the matter is by no means totally settled,

as the interesting discussion of the point in Huxley and Ingram (1971: 161–4) makes very clear, and relating emergence to such factors as socio-economic family background, sex, motor development, and so on, has hardly begun (but see below for some references).

What happens *after* the onset of non-segmental structuring is still an open question. There has been little attempt to trace systematically the order of acquisition of the different prosodic and paralinguistic features, to study the combinations in which they occur, or their distribution in relation to syntax and lexis during the second half of the first year and thereafter. Some of the theoretical and practical reasons for this have already been mentioned, at the beginning of the paper; but with fresh interest in intonation and related matters being shown by theoreticians (e.g. Chomsky 1970), and with developments in computational and acoustic techniques which reduce the processing-time of data, it is quite likely that progress, once it begins, will be rapid. On the face of it, there would seem to be two possible approaches. First, one might begin with some model of adult non-segmental behaviour, and do a 'reverse longitudinal study', progressively reducing the age-level of a sample, and noting the points at which the various features of the adult system cease to be used, or take on non-adult characteristics. This approach is obviously implicit in the observations of most of the scholars referred to in the preceding paragraph, but it does not seem to have been systematically tried, presumably because of the absence, until recently, of appropriate models of the adult behaviour. The second approach is the reverse of this – to study the developing characteristics of infant vocalizations to the point where they begin to be modified by language-specific characteristics, and to continue in the normal longitudinal way. This approach seems the more promising, for there are some fairly clear experimental procedures which would accumulate objective evidence about language specificity, which would not be totally dependent on one's preoccupations about the form of the terminal non-segmental system or on assumptions about the semantic function of the various patterns. For example, one could carry out cross-cultural studies which would show divergence in vocalization characteristics after a certain age: if the 6–7 mth hypothesis is valid, then after this point spectrograms (or other displays) of, say, Welsh and English children should begin to show regular and quantifiable differences, which could in turn be correlated with auditory judgments of informants (e.g. about the Welsh-soundingness of the children and physiological information

about the development of articulatory settings (cf. Honikman 1964). Or one could establish emergent differences between normal and deaf children after this age in a similar way. But any research along these lines presupposes that the characteristics of the infant vocalization, which provides the yardstick against which the language-specific features can be plotted, has been adequately specified. Increasing interest, therefore, is being shown by linguists in the general research which has been taking place into infant vocalization. Not only do these studies provide a wealth of descriptive information about the physical characteristics of vocalizations in the first six months in terms which tie in remarkably well with those that the linguist will need to refer to, they also lay down methodological guidelines which researchers into the later months would be foolish to ignore. An awareness of on-going research into early vocalization is thus in my opinion an indispensable perspective for any investigation of the onset and early development of non-segmental phenomena.

This research was only able to get under way once adequate techniques of recording, analysis and measurement had been devised – developments which took place largely in the 40s and 50s. Sound spectrographic techniques were of particular importance: they are referred to in detail in Lynip (1951), Murai (1960), Winitz (1960), Truby (1962), Tonkova-Yampolskaya (1962, and cf. the 'intonograms' of her 1968 paper), Wasz-Höckert et al. (1968) and the subsequent work by this group reviewed below, Ostwald (1963) and other work by this group reviewed below, Landtman et al. (1964), Wolff (1969) and Lenneberg (1967). Other techniques have involved phonophotography (e.g. Fairbanks 1942), kymography (e.g. Dittrichová and Lapáčková 1964), roentgen and cinefluorographic study (e.g. Bosma and Smith 1961; Bosma and Fletcher 1961); and Fisichelli and Karelitz's panoramic sonic analyser (1966). Earlier technical devices are reviewed in McCarthy (1929: 636ff.).

The most important outcome of recent research involving these techniques has undoubtedly been to specify the range of parameters needed in order to describe infant vocalizations as accurately and economically as possible, and to provide precise empirical data in these terms. Most of this work has used acoustic criteria of various kinds. Early on, Fairbanks (1942) studied the fundamental frequency of hunger cries from one to nine months, finding a variation from 63 to 2631 cps, with a mean of 556, a large and rapid rise in central tendency during the first

half of the period (373 – 1 mth, 415 – 2 mth, 485 – 3 mth, 585 – 4 mth), followed by a relatively stable, consistent, high level. Other potentially relevant dimensions (e.g. intensity) were not studied, however. Tonkova-Yampolskaya (1962) made an acoustic analysis of spectrograms of 18 neonates in the first six days, distinguishing a number of formant areas and describing the variations in intensity displayed. Ostwald (1963: 40) refers to glottal attack, vowel quality, fundamental frequency, pitch-range, loudness, and 'rasp' in his description of neonate cry. Other results are reported in Truby (1960), Lenneberg (1967), Kurtz (see Ostwald 1963: 18), Lieberman (1967: 41), and, much earlier, Sherman (1927), for whom cries had to be characterised by reference to intensity, duration, and type of onset and termination, as well as by tone quality. The most precise general description of early vocalization is Wolff (1969: 82ff). For him, the 'basic' cry is rhythmical, with a fundamental frequency of between 250 and 450 cps for either sex (concentrating between 350 and 400). A typical sequence consists of a cry (0.6 sec, mean duration) followed by a silence (0.2 sec m.d.), then a short inspiratory whistle (0.1 or 0.2 sec) at a higher fundamental frequency, and then a rest period (usually shorter than the first silence). There is a slight rise in frequency at the beginning which tapers off towards the end to produce a visual 'gentle arc' on a spectrogram. Wolff also distinguishes in the first week an 'angry' cry, which has the same temporal pattern, but excess air produces a turbulence and a distinctive 'distortion' (cf. Truby's 'paraphonation' 1962). Also in this period there is a 'pain' cry: this has a sudden onset of loud crying with no preliminary moaning, an initial long cry (4.2 sec m.d.), an extended period of breath holding in expiration (7 sec), an inspiratory gasp, and then further expiratory cries which settle down into the basic temporal pattern. In addition, Wolff notes a frustration cry, which starts like pain cries but has no breath-holding, and the inspiratory whistle seems perceptually to follow the initial cry (rather than to precede the second cry); and also a cry indicating gastro-intestinal discomfort, which has a higher average frequency (450–550 cps), is non-rhythmical and interspersed with shrill squeaks. In the third week of life he notes a 'faking' cry (where the baby is trying to get attention): this has a low pitch and intensity, a long, drawn-out 'moaning' quality (p. 98), a more complex spectrographic shape, especially at the cry terminal (where the direction of the pitch may rise, as opposed to the characteristic falling pattern of earlier cries), and the occurrence of fundamental frequency shifts dur-

ing the cry. At about this time, also, he notes the occurrence of the first non-cry vocalizations (e.g. gurgling), but finds it impossible to identify the point of transition on the spectrogram, though they are readily identifiable subjectively (p. 98). And in his concluding section, Wolff points out that there are a number of transitional types of cry which do not fit clearly into his major threefold classification (of 'basic', 'angry' and 'pain'), and considers any final typology to be premature (p. 86). It is clear from this work, and also that of Wasz-Höckert et al. (see below), that vocalization is not random, undifferentiated and non-expressive, as many earlier scholars had claimed.

The parametric identification of vocalization types, and the analysis of the conditions evoking vocalization can largely be described with reference to four groups of scholars. Firstly, there is a prolific group working largely in Scandinavia: see the introductory volume by Wasz-Höckert et al. (1968), which contains a recording, and associated bibliography under Bosma, Lind, Michelsson, Partanen, Valanne, Vuorenkoski, and Wasz-Höckert. They have established a set of parameters, using spectrographic analysis, which they claim will adequately categorize and distinguish a number of types of normal and abnormal (pathological) vocalizations, especially of pain cries; and the results of their most recent procedures using this method are certainly impressive, as the following summary (taken from Vuorenkoski et al. 1971) indicates:

> 'In order to get practical determinations of normality or degree of normality in the pain cry of an individual newborn and young infant, a new rating system, *cry score*, has been constructed. Sound spectrographic analyses were made of the pain cries obtained from 240 infants ranging in age from 0 days to 8 months. The values in 13 different cry characteristics were transformed into ratings between 0 and 4. Cry score, the sum total of the different ratings, was designated abnormal when it exceeded 3. The correspondence between diagnosis and cry score was very good: both the sensitivity and the specificity of the score exceeded 90% for groups of 120 normal infants and 120 infants in various types of serious pathological conditions and diseases... Repeated measurements of cry score in three pathological cases during the newborn period showed an interesting possibility to follow the clinical development in certain rapidly changing conditions' (p. 74).

The parameters specified in the early work (e.g. Lind et al. 1965; Wasz-Höckert 1968) are: length of cry (defined as the time between the first and last vocalizations of more than 0.4 sec); voice height (minimum, general and maximum); occurrence and height of a voice shift (i.e. a sudden upward or downward change in frequency); latency length (time between stimulus and cry onset); voicing (whether voiced, half-voiced, or voiceless); melody type (defined as 'a change in the

pitch level [sc. fundamental frequency, DC], when exceeding 10 per cent of the pitch during more than 10 per cent of the length of the cry' (Wasz-Höckert et al. 1968: 10), and subdivided into 'rising–falling' vs other types, which subsume 'rising', 'falling', 'abrupt', and 'flat' contours); continuity of the signal (whether continuous or interrupted); presence of glottal plosives within or between cries; presence of 'vocal fry' (also called 'glottal roll' or 'creak', i.e. 'an unperiodical phonation of the vocal folds in a lower frequency range, that is below the normal pitch register' (Wasz-Höckert et al. 1968: 13)); the occurrence of 'vibrato'; and the occurrence of 'subharmonic break'. In addition, information about head and chest voice, nasality and orality, and laxness and tenseness was obtained from auditory analysis of the tapes (voice, vocal fry, and subharmonic break were also rated auditorily). One should note that some of these parameters make use of auditory labels (e.g. the melody-types), even though they are defined largely in acoustic terms (of fundamental frequency, etc.). The classification, moreover, is not complete: some of the parameters are very general, and it is likely that further distinctions can be made within them. Also, the comparative importance of the parameters varies: some are considered to be more important characterizing features than others (e.g. Lind et al. 1966, measure cries in response to pain stimuli in terms of latency, signal length, length of second pause, and cry period only, these parameters being viewed as primary), and there is evidence of a hierarchical treatment, as in the grouping of melody-types. There is some suggestion that for the younger age-group of child, melody-form and length might suffice to discriminate the majority of signals; whereas for older children, other factors (e.g. nasality, voice shift) need to be referred to (Wasz-Höckert et al. 1968: 20–1).

As already indicated, much of this research has been carried out with a view to accurately diagnosing pathological neonate cries. Thus Lind et al. (1965) studied brain-damaged and normal children's cries and demonstrated that while latencies were similar, the height means were doubled for the former, the pitch-pattern was rising–falling (as opposed to falling), there were 80% shifts (as opposed to 30%), and there was no glottal roll. For hunger cries, length, height, glottal plosives, and roll were the most significant parameters. Vuorenkoski et al. (1966) studied the *maladie du cri du chat* syndrome in a similar manner, in terms of pitch types (rising–falling, falling, rising, falling–rising, flat and interrupted), vocal fry, subharmonic break, continuity, and expiration

or inspiration, and showed that the minimum pitch height was the optimum diagnostic parameter, with general pitch of being an important supporting factor. In 97% of cases, a minimum fundamental frequency of 500 cps was found. See also Lind et al. (1970) for the abnormal characteristics of Down's syndrome. This central significance of pitch height for diagnostic purposes is supported by other scholars, e.g. Ostwald et al. (1968), who however found no predictability on the basis of duration alone, in their analysis. Variations in duration as well as interval are however considered significant by Prechtel et al. (1969) in their study of normal and abnormal pain cries over the first nine days.

A second group working in this same field is in New York: see the bibliography under Fisichelli and Karelitz. Their 1962 and 1963 papers, for example, showed that brain-damaged children had longer cry latencies, emitted a less sustained cry, and required more pain stimuli to produce a given level of response than normal children. Wolff (1969: 94–5) found that brain-damaged cries tend to have a fundamental frequency of between 650 and 800 Hz; and similarly high fundamentals have been noted elswhere (e.g. for certain types of congenital heart disease). Fisichelli and Karelitz (1966) compared four normal and four mongoloid children at six months, and show that, while the frequency ranges do not differ significantly, normal cries were 'richer in spectral content', more active, less variable in sound level, and more homogeneous as a group. In another connection, it is also likely that the so-called 'deaf voice' which is developed by deaf children after an earlier period of normal babbling (cf. Fry 1966; Lenneberg et al. 1965) is ultimately correlatable with modified frequency range and direction and accompanying factors. Luchsinger and Arnold (1965: 348), for example, say: 'Another sign of early deafness in children is a typical change in the crying pattern. It sounds melodically distorted, more screeching and less emotionally differentiated than in normal children'. The point is beginning to be investigated: Manolson, for instance (1971), showed that hearing-impaired infants of 12–24 mth had significantly more and larger changes in fundamental frequency and amplitude, and used certain bandwidths more than normals.

A third group, also in the United States, is currently investigating abnormalities using spectrography and related techniques: see the bibliography under Ostwald and Peltzman. Ostwald et al. (1967) investigate the interesting possibilities of carrying out speech synthesis of

cries; and other papers carry out parametrically-oriented investigations of trisomy 13–15 children and the vocalizations of twins with cephalic union. Massengill (1969) and Massengill et al. (1966) have studied vocalization characteristics of children with cleft palate.

The fourth area of study comprises the work of a number of experimental and social psychologists who, over the past ten years, have been investigating the nature of the conditioning that affects vocalization. They have largely used 3-month-old children, and concentrated on non-crying vocalizations (as opposed to most of the work reported above). The question here is: what kind of reinforcement will affect vocalization? Rheingold et al. (1959) established that composite social reinforcement was an effective conditioner of vocalizations; Weisberg (1963) that only contingent social reinforcement was; see also Todd and Palmer (1968), Routh (1969), Wahler (1969), Sheppard (1969) and Kononova (1968). Tomlinson-Keasey (1972) has recently pointed out that much of this research has been on institutionalized children: upon examining reinforcement in a home context, he found that non-social reinforcement can increase rate of vocalization, *contra* many of the findings of the above. Also, much of the work so far mentioned has used complex stimuli in their experiments; recently there have been attempts to isolate the various relevant factors in the composite reinforcement that is generally presented. According to Schwarz et al. (1970), the various factors, either individually or in combination, can prove equally effective; and Haugan and McIntire (1972), for example, have separated food, tactile, and adult vocal stimuli (again with institutionalized children), examining the differential effect on rate, and showed that these factors can independently have a positive effect. A simple social reinforcer, especially the adult voice, can be as effective as a complex stimulus (e.g. involving touching, lights, etc.). Ramsey and Ourth (1971) have shown that immediate reinforcement is needed for a positive increase in vocalization rate. (For other work, see Beckwith 1971; Bell 1960; Chesni 1970; Cullen et al. 1968; Eisenson 1966; Fargo et al. 1968; Freedman et al. 1969; Gleiss and Höhn 1968; Kagan 1969; Landreth 1941; Reiber 1965; Solomon and Yaeger 1969.)

These are not the only research areas of relevance to language development in the first year. It is quite clear from the vast literature on audiometric testing and research, for example, that there are numerous important overlaps here with the interests of the linguist – for example,

the remarks by Bench (1969) concerning the possibility of innate pitch preference in neonates in order to account for an observed (inverse) relationship between effectiveness of stimulus and frequency, or the methodological discussion in Eisenberg (1965). Nor can I do any more at the moment than refer to the potential significance of the work of the ethologists for those interested in non-segmental studies. Many of the papers in Blurton-Jones (1972), for instance, draw attention to methodological emphases which have already emerged as desirable in the course of the present paper, e.g. the need for detailed description of individual interactions, and avoidance of premature conclusions about norms, a critical attitude towards vague behavioural categories. In some respects, the movement in vocalization study is in the same direction as that recommended by the ethologists, e.g. Bateson's (1971) concept of 'proto-conversations' between parents and children of between one and four months, indicating the emergence of regular patterns of interaction involving vocalizations. But to achieve even a modicum of success in this area, better monitoring systems are needed, to encompass a wider range of potentially relevant variables (see, e.g. Siegel and Sameroff 1971) and better systems of transcription and classification for the vocalizations are required (the attempts at transcription in Blurton-Jones need considerable refinement – interestingly, the bibliographies of the various papers in this volume show no awareness of the linguistic work going on in this field).

The existence of apparent contradictions between research findings, and the difficulty of comparing research programmes and reports indicates that there are numerous methodological problems which still need to be sorted out before any proper evaluation of progress in the above field can be made. The central question is the standardizing of the environmental conditions for eliciting vocalizations or when describing the context of their occurrence. In the case of pain cries, for instance (upon which most research has been done), what grade of stimulus is optimal, and what aspects of the cry does variation in stimulus affect? How does one ensure that the pain stimulus has been presented consistently, especially when techniques such as pinching or flicking the sole of the foot with a rubber band are used? And when should a given stimulus be applied? The physical and physiological controls required for experimental work into vocalization, particularly when of a statistical kind, are more complex than many scholars seem to realize, and psychological factors enter in very early on (the second week, according

to Wolff (1969)). A selection of reports shows this clearly. The results of Karelitz and Fisichelli and Vuorenkoski et al. are not easy to compare for this reason: the former removed the baby's clothes and obtained the cries before feeding, whereas the latter did not remove the clothes and obtained the cries afterwards; but it has long been known that clothing- and hunger-state has a marked influence on type and quantity of vocalization – see Aldrich et al. (1946) for the hunger factor, Irwin and Weiss (1934b) for results indicating that clothing reduces the amount of vocalization, and Wolff (1959, 1969: 89) for results indicating that swaddling does. Irwin and Weiss (1934a) amongst others reported that increased light and heat tend to decrease vocalization; Wolff (1969: 88–9) reported that higher temperatures make children vocalize less and sleep more; Pratt (1930) also found that certain temperatures decrease vocalization, but that humidity variations had no effect. Aldrich et al. showed that the amount of attention that a child is used to receiving is an important factor, and certainly the method of handling the children before a stimulus is applied or during a recording session needs to be looked into. To take a simple example, arm-rocking after feeding increases the quantity of vocalization (see Smitherman 1969). Brodbeck and Irwin (1946) showed the influence of orphanage environment on reducing the amount and types of vocalization. Ostwald et al. (1962) pointed to the significance of weight, size, physical development and general activeness in accounting for variability in results. Greenberg et al. (1967) suggested that early clamped children vocalize more, both spontaneously and after stimuli, than late-clamped – this being part of a general hypothesis that they are more alert. It is important to control the nature and amount of background noise in a research situation, particularly for older neonates, where the presence of human voices could make a significant difference to the results (cf. Wolff 1969: 97). The differential effect of types of sound as stimuli has been little studied: Stubbs (1934) showed that long intense sounds inhibited vocalization more than short, soft ones; Aldrich et al. in their 1945 and 1946 work, showed that continuous stimulation at mid-high intensity levels reduced vocalization intensity. Then there is the variable effect of male vs female reinforcement on vocalization: at 3 mth there seems to be no differential effect (cf. Banikiotes et al. 1972), but by 10 mth, there does (cf. Lieberman 1967: 44–6). When does this effect begin, and what are its determining factors? One possibility is that the father's voice plays an increasing role after 3 mth as opposed to its

minimal role previously (as reported by Rebelsky and Hanks 1971), providing the child with a clearer set of contrasts. Controls have to be strict here for longitudinal studies, as the vocalization pattern changes with maturation in response to any given stimulus, e.g. the 'infectious crying', or increase in vocalization on the part of a child while an adult is speaking, from between one and two months. The social importance assigned to vocalizations in the development of adult–infant interaction within a community must also be taken into account, as has been shown by Blount (1971) in his study of the Luo of Kenya. Wolff's (1969) review of infant vocalization should be referred to for other references and further discussion, in particular of those factors (e.g. visceral pain) which are not experimentally testable. He makes the important point that any of the predicted effects may vary if the 'state of the organism' varies (from the third week): a baby in an excited state will produce a different response to a given stimulus from one in a contented state, for example. (On the other hand, Lamper and Eisdorfer (1971), examining prestimulus activity level in relation to intensity of neonatal response and daily response consistency, show that while there is some interaction for mild stimuli, the activity state seems to have little relevance for more intense stimuli.) There have also been various negative findings about the determinants of vocalization patterns, which should not be ignored, e.g. Ostwald et al.'s (1962) result that various phonetic criteria failed to predict the difference in zygoticity of 16 pairs of twins much above chance; Ruja (1948), who showed that there was no correlation between the amount of vocalization in the first eight days and the length of labour; Karelitz et al. (1964), who tested an expected prediction that normal high IQs would have more active cries than low IQs, finding no real correlation; Fisichelli and Karelitz (1969), who showed that, while a more intense stimulus produced a more intensive cry, latency was unaffected: and Wasz-Höckert et al. (1968: 3), who found that racial origin had no differential effect on vocalization.

There are other factors which have to be borne in mind in evaluating the results of work in this field. In particular, it is likely that a more detailed differentiation of vocalization patterns would emerge if a more sophisticated analysis of their qualities was carried out. Much of the above research has been concerned solely with amount of vocalization, and not with its qualitative characteristics, as described in terms of parameters, features, etc. This is especially the case with the work on

conditioning outlined above: almost all these studies examined vocalizations in terms of the number used in given time-periods, and based their conclusions on quantitative measures alone. But variables such as fundamental frequency variation, frequency range, rhythm, speech register (see Weeks 1971) cannot be ignored for the 3-months+ period, in view of their demonstrated relevance for the classification of neonatal vocalizations, and their subsequent importance as part of the development of non-segmental patterns. Another factor in evaluating results is the method of carrying out the statistical part of the analysis – in particular, how the children and the vocalizations were sampled, and (for longitudinal studies) how they were divided in terms of age. For instance, Karelitz and Fisichelli have used very gross groupings of 0–3 days, 4–365 days, and 365 days plus. Vuorenkoski et al. on the other hand, had nine groupings in the first seven months. It is likely that statistical techniques will have to be further refined, as an increasing number of variables come to be discovered and need to be correlated (see further, Wasz-Höckert et al. 1964a, for suggestions on this point). A similar refinement is necessary for the spectrographic techniques. Almost all the evidence is based on spectrography, but it is well-known that the amount of accurate information obtainable spectrographically when there is a high fundamental is much reduced (cf. Fant 1968: 179–81; Lindblom 1962: 192; Lenneberg 1967: 276). Also, the vast amount of time required to make even a crude analysis of a spectrogram precludes large-scale visual processing, but satisfactory longitudinal investigations must necessarily be committed to large-scale sampling. In a preliminary survey recently, it emerged that the full analysis of a sample of vocalization material from six to eighteen months using spectrograms would take seven research assistants working full time on a faultless machine (sic) some fourteen years! In any case, it is only possible to obtain approximate values using such a method. It is clear that the practical problems of mastering techniques of analysis and transcription have been a considerable hindrance to scholars, particularly when – as is often the case in this field – they have had little or no formal linguistic training (cf. the difficulties of Haas and Harms 1963).

The obvious solution is to automate the process, so that a fundamental frequency analyser (or some similar device) could be attached to a 'black box' which would interpret this information in digital form, and present the output to a computer. Sheppard and Lane use such a

method for their research into infant vocalization: they investigate duration, intensity and fundamental frequency as a function of age of one child of either sex. Their results largely agree with Fairbanks (1942) as regards the magnitude and general movement of frequency. Specifically, at birth, male fundamental average was 438, lowering to 411 (approx. 21–45 days), and then rising to a stable 455; female fundamental was 401 at birth, lowering to 384 (approx. 21 days), and subsequently rising to 420. The coefficient of variation in fundamental frequency between utterances remained nearly constant throughout, i.e. utterances did not vary much in frequency, nor did fluctuation increase with age. About two-thirds of the fundamental frequencies plotted were within 10% of the mean. There was more variability in amplitude than fundamental frequency (longer utterances having greater amplitude). Average duration of the utterance became more uniform with increasing age (specific information here agreeing with Ringwall et al. 1965). They note a time-lag between the gradual disappearance of reflexive crying and the gradual appearance of motivated crying. I give these results in some detail to show that the scope and degree of specificity achieved by this survey are only really possible with the aid of a computer; it is clear that many of the practical problems which preclude large-scale research will diminish as this process is further used. For other normative data, see Ringel and Kluppel (1964), Wolff (1969), Truby and Lind (1965), Prechtel et al. (1969).

Other descriptions are a mixture of acoustic, auditory and articulatory characteristics. Ringwall et al. (1965) use distinctive features. Lynip's (1951) descriptions of early cries make use of seven partly acoustic, partly auditory parameters: pitch fundamental, attacks and terminations, time values, rhythm, cadences, resonances and intensities. Irwin and Chen's reliability study (1941) is carried out in almost purely articulatory terms: they show a 97% reliability of discrimination between 'crying' and 'whining' in terms of five parameters: breathing (regular and irregular respectively), mouth shape (wide and rectangular, and partially open respectively), tongue tip (elevated and not elevated respectively), face and lid muscle contraction (strong and slight respectively), and loudness (strong and feeble respectively).

3. Non-segmental patterning in older children

Despite the range of methodological questions still requiring answers

in work on early vocalization, a considerable amount of empirical information and descriptive technique has been established, and it should now be possible to apply some of this to the investigation of the non-segmental patterns of language proper in the second half of the first year, and beyond. Some absolute values have been established for different periods of development, right up to the teenage range, but this research has on the whole paid little attention to relating this physical information to the properties of the developing phonological system at any given point. See, for instance, Fairbanks (1950), Fairbanks et al. (in two 1949 papers), Curry (1940), Duffy (1958), Jones (1942), Levin et al. (1960, 1965, 1967), Hollien (1962), Hollien and Copeland (1965), McGlone (1966), Michel et al. (1966), Pedrey (1945), Bergendal and Söderpalm Talo (1969), and, on the recognition of intonation patterns, Corlew (1968). There have even been few transcriptions of samples of children's speech from the non-segmental viewpoint. Albright and Albright (1956) is an exception: they transcribe the utterance of a two-year old using the Trager–Smith system, and distinguish four degrees of stress (heavy, medium, light, very light), rising, fading and sustained clause terminals, three pitch levels, length and extra-length, nasalization, rounding and raising of vowels in his speech. Weir's 2½-year-old child (1962: 28–30) cannot be used for normative data, because of interference from Swedish and Czech, but it is a methodologically most interesting study. She too distinguishes three pitch levels, though they are not used contrastively with consistency. A fourth level, higher than any others, is used in calls and urgent requests. A sentence for her is a contour with a final fall, or rise, followed by a pause. A third, 'sustain' pitch is also possible. She summarizes the prosodic features of this age as unstable, countours being only occasionally and not reliably contrastive; pauses however are consistent. Other passing references to non-segmental features in the context of a linguistic system may be found in Benda (1967), Fargo et al. (1967), Tonkova-Yampolskaya (1968), Carlson and Anisfeld (1969), Leopold (1947, 1949), and Lieberman (1967).

Despite the absence of any reasonably complete descriptions of the non-segmental system at given stages of development, a certain amount of work has gone ahead looking at the way older children develop stylistically or sociolinguistically restricted linguistic behaviour using intonation and other features. Intonation is obviously an important mediating factor in many interaction situations: for example, in a three-

element pattern of (a) child's utterance (a question, perhaps), (b) parent's response, and (c) child's further response, the nature of (c) will be very dependent on the intonation of (b), whatever the syntax of the various utterances. The point does not seem to have been much investigated (cf. Brown 1958; Campbell and Wales 1970), though there are a number of relevant comments in the literature, e.g. Lewis's (1936: 151) distinction between declarative and manipulative functions of intonation (i.e. intonation which expresses moods, and intonation which draws attention to situations). Flavell (1968: 149) cites intonation, stress, loudness and rate as relevant for the description of role-playing, and this is supported by other observations, e.g. Ervin-Tripp (1964) on children's play intonations, and Burling (1966) on the metrics of children's verse. Carlson and Anisfeld (1969) note a joking tone of voice in their two-year-old subject, which was seldom used in imaginative play; and they refer to a style of speech which the child developed in situations in which he knew he was not allowed to do something but still wanted to, which they describe as 'fuzzy enunciation, very soft voice, and twisting of the head' (p. 575). I have heard a clear case of role-play in a child of 13 mth (in this case a switch to falsetto register when talking as he supposed – under an older brother's influence – a rabbit did). Barnard et al. (1961) distinguish 'voice' as one of their 'stylistic dimensions' in this study of anxiety correlates. Weeks (1971) makes a strong case in support of the hypothesis that children learn a number of speech registers (or styles) from a very early age, these being identified primarily in terms of non-segmental parameters; the detail of this analysis is welcome. Brooks et al. (1969) is a large-scale programme of research designed to establish social determinants involving the use of the non-segmental system. Working within the theoretical framework of Wiener and Mehrabian (1968), they study the responses of children from middle and low socioeconomic groups to verbal reinforcers communicated with and without tonal inflection. Positive reinforcement words (e.g. 'fine', 'good') and negative words (e.g. 'bad') were presented with a congruent inflection (a 3–1 glide in the Trager–Smith system) and uninflected (a level tone on 2); it was found that the low socioeconomic class responded more to verbal reinforcers which included inflection than to the same reinforcers when they did not; but the middle class did not show such a preference. A similar experiment using a negative tone ('characterised more by a rasping tone timbre than by uniformity of pitch contour') produced similar results: the middle class

showed no difference in response; the lower class responded only to inflected conditions – and more to positive words said with positive tone than negative words with negative tone. After some discussion of possible interpretations of these results, they conclude that the function of tone 'serves primarily as a language marker and then as an information bearer; that is, tone "directs" the child to the message carried in the semantic component, and in the absence of a marker, no response need be made to the word alone' (p. 469). See also Kashinsky and Wiener (1969). Finally, in the context of plotting the linguistic identity of social groups, Becker and McArdle (1967) examine what they call 'nonlexical speech similarities' in nonclinical families as an index of intrafamilial identification: average length and frequency of pause in wives and husbands, children and mother, and children and father provides some support for their hypothesis. Friedlander (1968) finds a preference among children between 11 and 15 mth for mothers over strangers or music, one of the bases for the preference being variation in 'inflection'. Gedda et al. (1960) present some evidence in favour of the hypothesis that monozygotic twins sound more alike as adults than dizygotic. Cameron et al. (1967), developing earlier work by Bayley (1932), suggest that the age at which babbling begins (in girls) is predictive of later intelligence scores. And Phillis (1970) presents some evidence suggesting that younger (junior high) children are more sensitive than older children or adults to nonlinguistic vocal cues (voice quality) in judging personality on the basis of voice types.

The relationship between non-segmental phonology and syntax in language acquisition has attracted a number of scattered observations, but remains almost totally unexplored. This is partly a reflection of the theoretical position adopted by linguists, which often dismisses non-segmental phenomena as marginally linguistic or 'mere performance'. Early work on generative grammar, for instance, paid next to no attention to intonation, and it is only recently that some scholars in this tradition have permitted intonation some role in determining semantic interpretation (e.g. Chomsky 1970). Other grammatical theories tend not to have been so narrow in their exclusion of intonation: it is seen as having a more central role in systemic grammar and functional sentence perspective, for instance, and researchers into child language using an approach based upon Fillmore's case-grammar have also permitted intonation and related features to play a central role (e.g. the University of Edinburgh Linguistics Dept. project). There is now considerable

agreement about the centrality of intonation in any investigation of the emerging syntax and meaning-relations of the first two years. Not many would adopt the fairly strong position of Braine (1963), that intonation is actually a vehicle for the learning of syntax; but a number of scholars would want to argue that intonation is the primary means of segmenting what would otherwise be continuous noise into 'sentencelike chunks' (as Weir put it, 1966: 153), so that units which are of semantic or syntactic importance can be isolated (see Kaplan and Kaplan 1970; Lieberman 1967; Crystal 1970). Moskowitz (1970: 14–17) sees intonation as a possible discovery procedure, not solely for sentence-units, but for subordinate syntactic units as well. The arguments by Bever et al. (1965) contra Braine, and supported for example by McNeill (1966: 53), that one needs prior knowledge of syntactic structure in order to carry out any analysis using intonation, are based upon a misapplication of the results of Lieberman's experiment (1965), as has been shown in detail by Kaplan (1970) and Crystal (1970). Apart from this, references to the use of intonation in relation to specific syntactic patterns are quite sporadic, and are usually couched in relatively vague terms (e.g. talking about 'rising contours' on a given structure, without reference to such matters as the extent of the rise in pitch, whether alternative contours are possible, and so on). Structures which have been noticed as requiring some intonational exponence include questions, negation, holophrasis, and presuppositions (see, for example, McNeill 1966: 55; Gruber 1967; Ingram 1971; Menyuk and Bernholtz 1969; many of the papers in Fillmore and Langendoen 1971; and the chapters on syntax in Menyuk 1971). But there are very many structures, which require intonational exponence in adult language, which have not been studied at all from the point of view of acquisition (e.g. relative clauses, appositional patterns, types of coordination). Blasdell (1969) and others are trying to provide a framework of analysis for the gestural, segmental and suprasegmental signs in the first language between 15 and 30 mth; they aim to provide, inter alia, an acoustic specification of the types of contours which appear to be equivalent to adult 'statement', 'question' and 'command' contours. I have not come across comparable projects for other syntactic structures of a more specific kind.

The innateness issue has of course been raised in relation to intonation, but the discussion which has ensued has produced no clearer answers than for any other area of language. Whether non-segmental

features have an innate basis or are learned is very much an open question. Most of the early scholars (e.g. Darwin 1877) felt that such patterns were instinctive, and there is some support for an explanation in similar terms still. The clearest arguments in support of innateness are in Lieberman (1967: ch. 3), who maintains that there is an innate physiological basis for the 'shape' of the normal breath-group, which occurs in very many languages. (His 'archetypal normal breath group' refers to a postulated pattern of articulatory activity which produces 'a prosodic pattern that is characteristic of the ones that are used to delimit the boundaries of unemphatic, declarative sentences in normal speech... We shall use the term "breath group" to encompas all the intonational signals that are acoustically or perceptually equivalent to the archetypal breath group' (p. 27). 'The presence of a basic synchronization between the laryngeal muscles and the chest muscles to form a basic intonation contour for a language, of course, explains how children acquire a "native accent" so quickly' (p. 29). According to Lieberman, 'It is a universal of human speech that, except for certain predictable cases, the fundamental frequency of phonation and the accoustic amplitude fall at the end of a sentence' (p. 26). This is an attractive hypothesis, but the fundamental concept of the 'hypothetical innate referential breath-group' requires considerable further substantiation and clarification before it can be accepted. There is some counter-evidence to the claim that short, normal declarative sentences end with a falling contour for all languages – it is not true for some dialects of Welsh or German, for instance (cf. Hlubík 1968) – and such terms as 'characteristic', 'unemphatic' and 'normal' in the first sentence of the above quotation need amplification. Lewis (1936: 49) took up a compromise position between innateness and learning hypotheses. Having noted that the child discriminates pleasant and unpleasant adult voice at three months, he states that this 'may in part be due to maturation of an innate tendency to respond to expression; but it is also likely to be due to training by the conditions in which the speech is heard' (e.g. the kinesics). Trojan (1957: 438) and Bolinger (1949: 249) have also argued that intonation is in some way tied to nervous tension; e.g. the latter states that 'intonation contains a few arbitrary uses, but they are embedded in a matrix of instinctive reactions... even the arbitrary uses may generally be assigned values consistent with the nervous interpretation'. I would however argue that most of the central 'core' of the intonation system of a language (and most of the prosodic system in

general) bears no relation to nervous tension, e.g. the splitting up of an utterance into tone-units, most of the contrasts in tonicity, the main oppositions of tone (falling, rising, etc.), and the less extreme contrasts of the pitch-range and loudness prosodic sub-systems (see Crystal 1969: 140ff. for this terminology). It is when one considers the formal extremes of articulation of a given feature (e.g. very high or loud speech) that one becomes aware of a partial physiological determination in the production of the effects (though this of course does not necessarily deny them a conventional role, as obviously the perception and interpretation of a finite number of contrasts along a parameter is something which may take place without reference to one's physiological resources). While one allows that there may well be an innate predisposition for the acquisition of prosodic features, as for the rest of language, then, there is no evidence to suggest that the features themselves are innate.

From all this discussion, it should be clear that the two main tasks facing the language acquisition scholar in this area are descriptive and methodological in character. Normative descriptive data is needed about many matters: the physical properties of infant vocalizations and non-segmental patterns, for any given 'state of the organism'; the changes in vocal behaviour between any given pair of states; the individual differences between children; the socioeconomic and dialect variations between children; the range of determinants (physical, psychological, physiological, environmental) which affect vocal behaviour; the norms of adult speech which elicit vocal behaviour (especially the non-segmental characteristics of 'baby-talk'); and the emergence of the affective, syntactic and social functions of the various vocal patterns. Particular attention has to be paid to the period between six and twelve months, and to the need for comparative analysis of the progressive differentiation of vocalization in different languages. From the methodological point of view, the primary task seems to be the development of more adequate descriptive frameworks, incorporating articulatory, acoustic, and auditory dimensions of classification and transcription. Also, for infant vocalization, an acoustic specification seems the most satisfactory technique of all, at the present stage of study, as the information it provides is fairly conveniently obtainable and precise (as compared with the articulatory approach) and to a very great extent avoids the dangers arising from the subjectivity inherent in the auditory approach (cf. above). But it is desirable as soon as possible to correlate

acoustic/articulatory and auditory information, so that the onset of non-segmental linguistic contrastivity can be studied in terms which are capable of correlation with the results of research upon older children and adults. At the moment it is not at all clear which method of description would provide the most accurate and consistent correlates of the various labels used in specifying the meanings of a non-segmental pattern. To label a pattern as 'happy', for instance, might best be correlated with acoustic data, or with articulatory data, or with auditory data. To avoid prejudging the issue, then, it would seem most satisfactory to make use of an approach in which all three kinds of information would be obtained to produce a complex specification of a label, until such time as one or other of the phonetic techniques turns out to be the most reliable diagnostic. In any event, research which does not make the basis of its descriptive techniques absolutely explicit (e.g. by using auditory labels in description of acoustic events) should be carefully avoided.

As Lewis (1936: 95) said: 'The whole question of intonation in children's speech is... extremely obscure'. It is depressing, nearly forty years later, still to have to agree with him.

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