THE ACQUISITION OF PHONOLOGY

A CASE STUDY

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Introduction

It is obviously true that the speech of young children differs radically from the speech of adults, but that children end up speaking essentially identically to their parents. It is equally, though perhaps less obviously, true that this deviation from the adult norm is non-random in character, and that the child's performance differs in regular and predictable ways from that of his putative models.

Given these facts and a child learning English, I decided to attempt a characterisation of the child's language in rigorous linguistic terms in order to establish the nature of these regularities. What I expected to find was a constantly developing and interacting competence and performance[1] unique to the child, moving steadily from a more idiosyncratic and simple system to one which was more complex and more closely isomorphic with the system of the adult language: a progression reflecting the supposed universal hierarchy sketched most clearly and succinctly in Jakobson's 'Les lois phoniques du langage enfantin' (Jakobson, 1949). However, although the child's performance was immediately accessible for observation, it was by no means self-evident what the nature of his phonological competence was. Accordingly the data were analysed simultaneously in two ways: one assuming that the child's competence was essentially idiosyncratic and roughly equivalent to his performance; one assuming that the child's competence was essentially equivalent to the input he was exposed to – i.e. the adult language.

It soon became apparent that there was a wider range of phenomena in the child's process of language acquisition to be explained than is indicated in the opening paragraph above. In addition to the mere fact of regularity, any theory of language acquisition must be able to account for at least the following classes of data observed in the acquisitional process:

(1) *Exceptions or the non-random nature of irregularities in the acquisition process.* After starting out by saying that the most striking fact of language acquisition is its regularity, it may seem paradoxical to continue

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[1] In the sense of Chomsky, 1965; see esp. p. 4.

by emphasising irregularities. However, an example of each should make matters clear. If the child's phonological acquisition is regular, this means that once the correlations between the adult system and the child's performance have been worked out, one can correctly predict the child's output for any arbitrary word of the adult language. For instance, observing that a child said:

> [wiːt] for *feet*
> [wiŋə] for *finger*
> [wæː] for *fire*

and so on, one could correctly predict his form for *fork* – namely [wɔːk] – with a [w] regularly substituting for /f/ in initial position.

However, there was a small class of exceptions to this generalisation, of which the clearest was *feather* which, instead of the expected *[wɛdə], became [tɛdə]. At first sight inexplicable, this item was later seen to fall naturally into a class of 'restructured' elements where /s/ and /f/ were frequently interchanged by the child; although, as adult /s/ was regularly realised as [t] at this stage, the appearance of [t] for /f/ was apparently random but actually easily explicable. The details of this rather complex process are not relevant at this stage of the exposition, and are taken up in detail in chapter 4. What is relevant is the general importance of exceptional features in the acquisition process; since, despite being exceptional, these are usually not random and frequently provide evidence for the nature of unexceptional forms. Indeed, the importance of exceptions and the need specifically to characterise the form of their exceptionality is one major reason for the massive documentation of rules and forms apparent in this monograph. If an argument hinges on the interpretation of an abnormality, the facts of normality must be established unambiguously first.

(2) *The many–many correspondence of segments in the child's system to those in the adult system.* The regularity mentioned above must not be interpreted as implying a one–one correspondence between terms in the child's system and those in the adult system. Thus adult /l/ was realised by the child:

> sometimes as [l]: e.g.   *lorry* → [lɔliː]
> sometimes as [d̪]: e.g.   *light* → [d̪ait]
> and sometimes as [ġ]: e.g. *like* → [ġaik]

Likewise, adult /s/ was differentially treated as:

> ∅ e.g.   *sun* → [ʌn]
> [ġ] e.g.   *sock* → [ġɔk]
> [t] e.g.   *mice* → [mait]
> or [b̪] e.g. *whistle* → [wib̪u]

Whereas in different environments all of adult /t, d, s, z, ʃ, ʒ, θ, ð, tʃ, dʒ, r, l, j/ might be neutralised as [d̪], as in:

> *teeth* → [d̪iːd̪] or [d̪iːt]
> *door* → [d̪ɔː]
> *scissors* → [d̪idə]
> *zoo* → [d̪uː]
> *shirt* → [d̪əːt]
> *garage* → [ġæəd̪]
> *there* → [d̪ɛː]
> *chair* → [d̪ɛː]
> *John* → [d̪ɔn]
> *rain* → [d̪eⁱn]
> *lady* → [d̪eːdiː]
> *yes* → [d̪ɛt]

In all these cases the child's substitutions were regular, in the sense of being purely phonologically conditioned, and merely demonstrate the complexity of the relationship between adult and child forms. They were not exceptional in the way the substitution in *feather* was.

(3) *The across-the-board nature of changes in the child's developing phonology.* Regularity is characteristic of the child's phonological behaviour not only at one specified point in time, but also longitudinally through time. That is, changes in the child's output occur virtually simultaneously to phonologically defined classes of items and not piecemeal to individual lexical items. Thus when initial [f] was produced correctly, it was substituted at essentially the same time for all the words beginning with /f/ in the adult language, and for none of those beginning with /w/, even though /f/ and /w/ were neutralised as [w] in the child's early output. Accordingly the examples cited in (1) above became: [fiːt], [fiŋə], [fæːr] and [fɔːk] at stage 15, while *window*, *wash*, and so on remained with an initial [w].

One caveat remains to be made to the above statement: namely, that a change from say [w] to [f] was in the nature of things rarely absolutely

abrupt, and there was frequently a brief period when words with an adult /f/ were realised alternatively with [w] and [f]. Such free variation never occurred in words with an adult /w/.

(4) *The appearance of non-English sounds or sequences in the child's phonology.* In many cases the child produced quite regularly sounds or sound sequences which do not occur in the adult language. For instance, voiceless sonorants [ɬ, m̥, n̥] as in:

slug → [ɬʌg]
Smith → [m̥is]
sneeze → [n̥iːd]

or an initial velar nasal, [ŋ], as in:

neck → [ŋɛk]
snake → [ŋeːk]

(5) *Puzzles.* The most interesting instance of the many–many correspondence cited above is provided by the phenomenon of 'puzzles'. That is, the child appears unable to produce a particular sound or sequence in the correct place, but is perfectly capable of producing it as his interpretation of something else. For instance, by completely regular rules *puddle* was pronounced [pʌgəl] whilst *puzzle* was pronounced [pʌdəl]. That is, we have the array:

/pʌzəl/ → [pʌdəl]
/pʌdəl/ → [pʌgəl]

(6) *Recidivism.* That is, the loss of a contrast which has already been established. For instance, at the stage where /s/ and /l/ both became [d̥] for the child, *side* and *light* fell together as [d̥ait]. Then as [l] was correctly reproduced for the adult /l/, a contrast developed resulting in the differentiation of these items as: *side* → [d̥ait] and *light* → [lait]. However, the next relevant change in the child's system was the substitution of [l] for the adult /s/, so that the two items fell together again as [lait]. That is, we have a progression from a stage where there is homonymy:

$$\left.\begin{array}{r} side \\ light \end{array}\right\} \to [\text{d̥ait}]$$

to a stage where the items are differentiated:

side → [d̥ait]
light → [lait]

and then a further stage where there is homonymy again:

$$\left.\begin{array}{r} side \\ light \end{array}\right\} \to [\text{lait}]$$

(7) *The child's ability to understand his own speech.* That is, the child can understand imitations or tape-recordings of his own speech, provided these are representative of the stage of development that he is at. For instance, if he hears [səːt], he will correctly identify this as *shirt, if* this is how he still pronounces it. There are further qualifications to this ability which need not be elaborated until the relevant section.

These various phenomena, among others, are accounted for at an observationally adequate level[1] by the two rule-based analyses which were mentioned earlier and descriptions of which are given in chapter 1. Both analyses are treated synchronically: that is, taking the first stage studied as a static system (chapter 2) and also diachronically or longitudinally: that is, tracing all the changes in this system over a period of some two years (chapter 3). Having thus juxtaposed and compared these two analyses, it is then demonstrated in chapter 4 that, contrary to what might be expected either *a priori* or on a superficial inspection of the classes of phenomena listed above as being in need of explanation, only the analysis which presupposes an adult competence for the child and which treats the child's phonology as a mapping from the adult's system attains descriptive adequacy. This is seen to be true in that all these phenomena can be explained in terms of such an analysis whereas only a fraction of them can be explained under the assumption that the child operates an autonomous system. More importantly, each part of the analysis is motivated independently and a set of putatively universal constraints on both the form and function of mapping rules between adult and child language is proposed.[2] The section ends with a suggested psychological model able to account satisfactorily for the phenomena described. The last chapter (chapter 5) is devoted to a discussion of various substantive problems in phonological theory on which it is suggested that phenomena of acquisition may cast light.

For reasons already touched on above, and as most accounts of language acquisition raise questions in the minds of the readers which never

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[1] Cf. Chomsky, 1964, esp. pp. 925–7, for a discussion of levels of adequacy.
[2] If these constraints are indeed universal then the analysis has, at least in part, attained a level of explanatory adequacy; see Chomsky, 1964, pp. 925–7.

occurred to the writer, I have included, as Appendix C, a comprehensive diachronic lexicon of the items on which the present study is based. It is hoped that this material may both be of use to other researchers and also, of course, provide a detailed enough corpus for the validity of my own claims to be checked by those interested.

I   *Background*

1.1   The child and his milieu

Although observations of other children speaking English and other languages have been made intermittently, this book is specifically a case study of one child learning to speak English Standard Pronunciation (ESP),[1] or at least something isomorphic to ESP. The following background details may indicate that the assumption that it is ESP being learnt is, strictly speaking, unrealistic, but it is justified in as much as there appear to be no features of the child's language which are crucially affected by differences from the standard language.

The child, Amahl ['æma:l][2] (hereinafter A), was born on 4 June 1967 in Boston, Massachusetts, of an English father and an Indian mother, and stayed in the U.S.A. until his first birthday, when he came to the U.K. Thus, although he did not speak until much later, A was exposed to a considerable amount of American English at a stage when he was gaining an at least latent knowledge of the language.

The father's (my) English is ESP with some minor deviations from what is normally considered the 'Received Pronunciation'. Specifically these are:

(1) The use of tense /i:/ in unstressed final position in words such as *city*: /siti:/ instead of RP /siti/.
(2) The occasional (random) use of pre-consonantal and final /r/.
(3) The occasional (random) use of pre-vocalic 'dark' /l/ ([ł]).
(4) The glottalisation of /d/ pre-consonantally and finally.
(5) The use of a flapped [ɾ] for post-consonantal /r/.

For A's mother, a medical doctor, English is the fourth language, following Hindi, Bengali and Marathi. She speaks 'Standard Indian English' which, although phonetically widely different from ESP, is structurally not dissimilar. The most important divergences are:

(1) The regular use of pre-consonantal and final (but not intrusive) /r/.

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[1] See Trim, 1961.
[2] Frequently mispronounced outside the family as [æ'ma:l] or [ə'ma:l]. When embedded in a Hindi sentence, normally: [əməl].

(2) The neutralisation of the /v – w/ distinction (in favour of a bilabial, usually frictionless, continuant).

(3) The neutralisation in fast speech of the /ɔ – ɔ:/, /əu – u:/ and /ei – ɛ/ distinctions.

The major phonetic differences are the usual ones:

(1) The monophthongisation (to [e:]) of /ei – ɛ/.
(2) The greater tenseness of all vowels.
(3) The retroflexion of /t, d/.
(4) The fuller voicing of voiced obstruents.
(5) The occasional confusion of /s – ʃ/ when both sounds occur in the same word.

For five months, from the age of 19 months to two years, A lived with his paternal aunt (my sister). Her dialect is ESP, as is that of her husband and two children; the latter aged two years older and two months younger than A. The onset of A's speech was late (around 20 months) and occurred within this period. Accordingly, data for the very early stages of acquisition are inadequate for fully explicit rules representing them to be formulated, and concentrated study did not start until the end of the twenty-fifth month. However, this lacuna is not serious as the earliest stages are those most adequately covered by earlier researchers, and are also phonologically the least complex.

From 26 months A, together with his parents, spent six weeks in India where he was exposed to considerable Hindi and Marathi. However, he has been brought up monolingual and, although he had a slight receptive knowledge of Hindi for some months, speaks none.[1] He has never had any knowledge of Bengali or Marathi.

From 30 months he has been attending day nurseries, play groups and nursery schools in Luton and Harpenden (Bedfordshire and Hertfordshire respectively), whence he has acquired some distinctly non-ESP diphthongs.

In general A is lively and intelligent[2] with a large vocabulary. He has no irregularities of the speech organs or hearing.

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[1] His reaction to being enjoined to speak Hindi, or even being addressed in it, was usually anger. On the few occasions when he did say anything in Hindi, it was with an English accent. For instance, his response to [əməl lərka hai] ('Amahl is a boy') was [æməl nɔt ə lɔːkə, æməl ə boi] ('Amahl is not a "lurker", Amahl's a boy').

[2] In an IQ test (Stanford–Binet) administered at 4 years 4 months, he scored at the 6 year 6 month level. On Raven's Progressive Matrices he scored at the 6-year level.

1.2 The linguistic theory presupposed

The theoretical framework for the description is that of generative phonology as set forth in Chomsky and Halle (1968) and Stanley (1967). Familiarity with the notions and notations of these works is presupposed in the formalisation of the rules and in several places in the theoretical discussion of individual points of interest. Elsewhere, however, familiarity with elementary phonetics and phoneme theory should be sufficient to enable the reader to assimilate the core of the book. Where any inconsistency between the formal and informal descriptions arises (as the result of a difference in detail, for instance) the formalised version is to be taken as definitive.

1.3 The method and scope of study

1.3.1 Method. All the data analysed were taken down in phonetic transcription on index cards. A tape-recorder was used occasionally,[1] especially when testing A's response to his own speech, but most of the description is based on non-recorded material. In most cases the data were spontaneous utterances from the child, although on some occasions recourse was had to asking him to name things, e.g.:

NVS What's this? [pointing to the telephone]
A   [dɛwiːbuːn]

Where it was particularly desired to elicit a form which illustrated (or it was suspected would illustrate) a special phenomenon, I would ask him, all else having failed, to say a word:

NVS Say 'zinc' *or* Can you say 'zinc' for me?
A   [ġik] *or* [wɔt ġik ḍɛdiː] (What's 'zinc', Daddy?)

All such directly elicited examples are enclosed in parentheses in the text and in Appendix C; e.g. '(zinc – [ġik])'. In general A was a good and willing informant, and I do not think this elicitation is in any way misleading. Typically, a sound or contrast he was able to repeat after me, he would be able to produce spontaneously a few days or at most a few weeks later. The usual response, when he was asked to say something 'correctly' after he had already attempted to say it in his own way, is exemplified by the following dialogue, recorded when I was puzzled by

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[1] I am grateful to Dr Adrian Fourcin for making a tape-recorder available to me for part of the study.

his ability to pronounce the nasal in *hand* ([ɛnd]) but not in *jump*:

NVS Say 'jump'
A   [dʌp]
NVS No, 'jump'
A   [dʌp]
NVS No, 'jummmp'
A   [uːliː dɛdiː ġæn dɛː dʌp] ('Only Daddy can say "jump"')!

By contrast, on one or two occasions, he spontaneously came up to me and announced his ability to produce a new sound or sequence. Thus after rendering *quick* as [kip] quite regularly for a year or more, he suddenly said: 'Daddy, I can say [kwik]'; without, to my knowledge, having been in any way prompted.

Data were collected systematically from 2 years 2 months to age four; sometimes at intervals of a week, sometimes every day; depending partly on the (in)stability of his system, partly on the time available. If I detected any change at all in what he said, I always made a note of it, with the result that I am confident that only minor changes can have been missed over the period studied. The only lengthy gap occurred during the visit to India when, deliberately, only isolated jottings were made.

1.3.2 Scope. With the exception of a brief discussion of certain grammatical conditionings of the acquisition of phonology, this study is devoted exclusively to the sound system of the language.[1] Even within phonology emphasis has been placed very heavily on the consonant system, with details of intonation or the vowel system given only when they cast light on the consonants. The reasons for this are:

(1) The development of the consonant system was much more complex, and therefore gave rise to a greater number of theoretically interesting phenomena. As far as I know there were no classes of phenomena evidenced by the development of the vowel system which were not manifested more clearly by the consonant system.

(2) The impracticability of using a tape-recorder consistently in the early stages made the analysis of intonation extremely difficult.[2]

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[1] I have excluded all details of the non-linguistic, cognitive, development of A for a number of reasons. First, as a linguist not a psychologist, I am not competent in this direction; second, I strongly suspect that the general cognitive development of the child is not relevant to his acquisition of phonology, even though it certainly is in his acquisition of syntax/semantics; third, the human life-span is finite.

[2] Elsewhere the use of a tape-recorder is not as helpful as might be expected. It is no use having a perfect recording of [ġʌk], if you do not know whether it corresponds to the adult *dog, duck, luck, truck* or *stuck*.

(3) A's mother's speech differs more from ESP in the vowel than in the consonant system (cf. p. 7 above).

(4) There was far more phonetic free variation in the vowel system than in the consonant system, which made the details of the analysis less clear-cut.

(5) There is far more dialectal and idiolectal phonetic variation in the vowel system than in the consonant system of English, and A was exposed to an unusually wide cross-section of dialects.

1.4   The method of analysis

As mentioned in the Introduction, A's phonology is analysed in two quite distinct ways: first as a function of or mapping from the adult language which the child is assumed to be learning (ESP); and second as a self-contained 'independent' system, in much the same way as one would analyse any unknown language.

1.4.1 The child's phonology as a function of the adult language. This part of the analysis consists at each stage of a single set of ordered rules which have as their input the adult surface forms (cf. the father's English characterised above), i.e. those forms to which the child is exposed, and maps these into the forms of the child's system (cf. 1.4.2 below). The rules are couched in terms of distinctive features, but for the sake of clarity examples are given in phonemic transcription. Thus, to take the example of *zinc* quoted above, we start with the adult form /ziŋk/ and apply to it a set of rules which result in the child's form [ġik]. To oversimplify, this involves two rules:

(1) A rule deleting the nasal before a voiceless consonant.
(2) A rule converting /z/ to [ġ] when the /z/ begins a syllable which closes with a velar.

Although these rules seem *ad hoc* in isolation, it will be seen later that they are actually extremely general. It will also become apparent that at least one further rule must apply in the derivation of [ġik] from /ziŋk/: specifically, one which neutralises the voicing distinction between /k/ and /g/. Given that there is no phonemic distinction of voice in A's speech, the form [ġik] is representable phonemically as |gig|,[1] and the contrast between the initial and final segments is due to phonetic rules internal

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[1] For the abbreviatory notations used here, see p. viii, above. Briefly, |×| = adult phonemes; |×| = A's phonemes; [×] = phonetic representation.

to A's phonology. In other words, the rules mapping ESP onto A's system have as their input the adult phonemic form, and as their output the child's phonemic form prior to the application of the phonetic rules of his own system. The theoretical status of these rules is discussed in detail in chapter 4.

1.4.2 The child's phonology as an independent system. This part of the analysis is subdivided into three:

(1) A list of those segments which are phonemically distinctive for A's idiolect, characterised in terms of a matrix of distinctive features. Technically, this is a distinctive feature specification of the systematic phonemic elements of the language; traditionally, a phoneme inventory.[1]

(2) An unordered set of morpheme structure conditions (see Stanley, 1967) accounting for the restrictions; segmental, sequential and canonical, on the set of features displayed in (1). *Inter alia*, these conditions characterise the structure in terms of consonants and vowels of all the items in the child's vocabulary; state restrictions on the appearance of specific segments in certain positions, e.g. that *h* cannot occur finally; state redundancies in the matrix of (1) and provide indirectly an enumeration of the 'structural types' typical of Waterson's study (Waterson, 1971*a*).

(3) A list of phonetic rules internal to the child's own idiolect. For instance, rules giving the distribution of voiced and voiceless plosives at a stage before these are distinct.

Both types of analysis, the mapping from the adult language and the independent, are treated diachronically as well as synchronically. That is, sets of rules for a particular stage of the child's acquisition are set up, and then changes in his phonological output are characterised in terms of changes to these sets of rules. In other words, the developmental changes are treated as changes of rules controlling the realisation of classes of items, not as changes of individual items.

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[1] The distinction between a traditional phoneme inventory and a generative phonology's set of underlying segments (as exemplified in, e.g., Chomsky and Halle, 1968, pp. 176–7) is largely neutralised, as the child's highly restricted phonological system displays none of the alternations which chiefly motivate such a divergence. (For discussion, see pp. 180f. below.)

2   *The child's phonology at two years*

The first stage of A's acquisition of speech for which data are virtually complete dates from 2.60[1] and I will take this as the *point de départ* for all the analysis presented.

2.1   A's phonology as a mapping from adult English

2.1.1 Informal exemplification of the realisation rules. To express the regular relationships between A's phonology described as a self-contained system below and the phonology of the language which he was acquiring, I have formulated a set of REALISATION rules which take the adult surface form as input and give the child's form (prior to the application of phonetic rules) as output. These rules are strictly ordered, and any adult form will be subject to any rule which is applicable.[2] Discussion of and justification for the ordering will be given after the formal statement of the rules on pp. 22–30 below.

Aside from a few exceptions, dealt with in section 2.1.4, the following rules predict the treatment of any word of ESP by A:

(1) A nasal consonant is deleted before any voiceless consonant.

stamp → ḍɛp[3] phonemically |dɛb|
bump → ḅʌp phonemically |bʌb|
drink → ġik phonemically |gig|
tent → ḍɛt phonemically |dɛd|
uncle → ʌgu phonemically |ʌgu|
empty → ɛbi: phonemically |ɛbi:|
thank you → ġɛgu: phonemically |gɛgu:|

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[1] A's age is given in years and days to avoid the problem of dealing with fractions when changes occur within a month or even a few days of each other. See Appendix A.

[2] See the sample derivations in 2.1.3 below.

[3] In the exemplification the forms are given as if all rules had applied. Moreover, although the output of the realisation rules gives a phonemic representation (displayed only for rule R1), the words are actually cited in a phonetic transcription: i.e. assuming the application of the phonetic rules (see 2.2.4 below). Square brackets are omitted from tabulated examples.

(2) A voiced consonant is deleted after a nasal consonant.

window → winu:	angry → ɛɲi:
mend → mɛn	round → ḍaun
handle → ɛɲu	hand → ɛn
finger → wiɲə	band → ḅen

Taken together, rules R1 and R2 account for such (later recorded) minimal pairs as:

mend → mɛn
meant → mɛt

(3) The alveolar consonants /n/ and /t, d/ become velars, [ŋ] and [g] before a syllabic [ḷ].

handle → ɛɲu	beetle → ḅi:gu
pedal → ḅegu	bottle → ḅɔgu

This is one of the most widespread rules found in children acquiring English as their first language. It is noteworthy that with A it applies only to the stop consonants; continuants (/s, z/ etc.) are not affected, cf. the example of *puzzle/puddle* discussed in the Introduction (p. 4), and the example:

whistle → wibu

and neither are the affricates /tʃ, dʒ/. At this stage there were no examples of affricates in this position, but later (stage 23), when the rule was still operative, words such as:

cudgel → kʌdᶻəl
satchel → sætˢəl

indicate that only stops are involved. It will be observed later that the conditioning environment is not only syllabic [ḷ] (or [əl]) but any [l] after an alveolar stop:

antler → æŋklə (stage 28)

It is of interest that a comparable rule has been observed in children acquiring German as their first language. For instance, I have heard a two and a half year old German boy (C) regularly produce the following:

Dreck → glɛk
Andreas → æŋˈgleːəs etc.

where the uvular [R] has apparently imposed velarisation of the preceding alveolar, before itself becoming an alveolar lateral.

(4) Syllabic [ḷ] vocalises to [u]; e.g. the examples given for R3 above, and also:

apple → ɛbu	tickle → ġigu
nipple → mibu	uncle → ʌgu
table → ḅeⁱbu	

The question whether this rule should be expressed in terms of syllabic [ḷ], [əl] or what, is discussed below, p. 24.

(5) In some cases a continuant consonant preceded by a nasal and a vowel, itself becomes a nasal.

noisy → nɔ:ni:
penis → ḅinin
smell → mɛn

This rule is somewhat marginal as there are just as many cases where it does not apply as where it does:

nice → nait
mice → mait
Smith → mit

(6) /l/ is deleted finally and preconsonantally.

ball → ḅɔ:	bolt → ḅɔ:t
bell → ḅɛ	elbow → ɛbu:
trowel → ḍau	milk → mik
wheel → wi:	

(7) /s/ is deleted preconsonantally.

biscuit → ḅigik	spoon → ḅu:n
escape → ġeip	scream → ġi:m
skin → ġin	swing → wiŋ
Smith → mit	

This too is an extremely widespread rule, and is probably universal[1] although later development of the rule may give rise to a superficially contradictory set of examples (see p. 167 below). Although no examples occurred at this stage, it should be noted that /s/ was not deleted before /j/.

(8) In a word of the structure /CwCV/ the second consonant becomes bilabial. That is, whenever an initial consonant is immediately followed by /w/, the next consonant assimilates to [p], [m] or [f].

[1] Obviously restricted to those languages which have clusters of /s/ plus consonant.

Although this rule was completely regular for a prolonged period, all the clear examples come from later stages, e.g. from stage 9:

squat → ġɔp   twice → ḍaif
squeeze → ġi:ḅ `   queen → ġi:m

The only evidence for this rule at stage 1 is the solitary example of:

bird → ḅi:bi:p

where what A was really attempting to say was 'tweet-tweet'. Note that rules R7 and R8 give very clear evidence of the need for ordering. That is, the sequences /sw/ and /Cw/ (where C is any consonant but /s/) behave quite differently. Thus:

sweetie → wi:di: (/s/ → Ø by R7)

but: twice → ḍaif   (/t/ is retained, as [ḍ]; the /w/ causes the final consonant to become [f], and is itself later deleted by R16).

(9) In a word of the structure /sVC/ the /s/ is optionally deleted if the C is labial or alveolar.

soup → u:p   seat → i:t
soap → u:p   sun → ʌn

This rule is optional to account for:

sun → ḍʌn (in free variation with [ʌn])
scissors → ḍidə
soon → ḍu:n

The important point is that when the following consonant is a velar the rule can never apply:

sing → ġiŋ
sock → ġɔk

(10) In a word of the structure /ʃVC/ the /ʃ/ is optionally deleted if the C is labial or velar.

sharp → a:p
sugar → ugə

This rule is optional to account for:

shopping → wɔbin

Data are rather scarce for both this and the preceding rule, R9, but it is important to notice here that /ʃ/ was never deleted before alveolars:

shirt → ḍə:t
shine → ḍain
shoulder → ḍu:də

The diachronic development of these two rules is interesting (see p. 65 below).

(11) /z/ is deleted finally.

The most obvious effect of this rule is to eliminate the distinction between a large class of singulars and plurals:

eye/eyes → ai
shoe/shoes → ḍu:

Moreover, as A had no contrast anywhere between singular and plural, e.g. [wut] and [wi:t] were in free variation for both *foot* and *feet*, it is probably the case that other non-plural or *pluralia tantum* examples of this rule:

nose → nu: glasses → ġa:gi:
please → ḅi: scissors → ḍidə

had been analysed by him into a stem and a plural morpheme. That is, we have an indirect example of the grammatical conditioning of A's acquisition of phonology. (For further discussion, see pp. 67f. below.) It should be noted that /z/ was differently interpreted elsewhere:

zebra → wi:bə
lazy → ḍe:di:

and that /s/ in final position was not deleted:

kiss → ġik
mice → mait

(12) A nasal consonant following an unstressed vowel becomes alveolar: [n].

bottom → ḅodin   working → wə:gin
crying → ġaiin   taking → ġeigin
driving → waibin

The only exceptions to this rule occur if the consonant immediately preceding the unstressed vowel is itself a velar nasal, in which case an ESP

velar nasal is retained. Thus beside the examples above, we have:

singing → g̣iŋiŋ

(and later) longing → lɔŋiŋ

banging → bæŋiŋ etc.

Nearly all the examples of the operation of this rule involve the verbal suffix *-ing*, but there were some later examples which indicate that the conditioning environment was in fact phonological not syntactic:

| ceiling → li:lin | something → wʌpin |
| pudding → ḅudin | nothing → nʌtin etc. |

(13) /h/ is deleted everywhere.

hair → ɛ	head → ɛt
hammer → ɛmə	hurt → ə:t
hand → ɛn	

(14) An initial or post-consonantal unstressed vowel is deleted.

| away → we: | banana → ḅa:nə |
| escape → g̣e:p | belong → ḅɔŋ |

The perhaps unexpected inclusion of the last two examples here is obviously dependent on the operation of further rules (in fact, R16).

(15) /t/ and /d/ are optionally deleted before /r/.

driving → waibin

troddler → lɔlə (a kind of pedal-less bicycle)

trolly → lɔli:

In fact this rule is very marginal: the three examples cited are the only ones affected, and it may well be better simply to treat these as exceptions (see the formalisation of this rule below, p. 28).

(16) Post-consonantal sonorants, /l, r, w, j/ are deleted.

angry → ɛŋi:	flower → wæwə
brush → ḅʌt	play → ḅe:
crumb → g̣ʌm	new → nu:
cloth → g̣ɔk	bird → ḅi:bi:p (see above, p. 16)

This is another extremely widespread rule with claims to universality: at least as far as the deletion of /l/ and /r/ is concerned. Note that the term 'sonorants' covers the nasals as well as liquids and glides, thereby allowing R16 to produce, for instance:

banana → ḅa:nə

via the intermediate stage – bna:nə – occasioned by rule R14.

(17) Non-nasal alveolar and palato-alveolar consonants harmonise to the point of articulation of a preceding velar.

cloth → g̣ɔk	good (night) → g̣ug (nait)
glasses → g̣a:gi:	coach → g̣o:k
kiss → g̣ik	kitchen → g̣igən
biscuit → ḅigik	

The rule excludes nasals because of such examples as:

skin → g̣in

corner → g̣o:nə

There was one exception to the rule:

greedy → g̣i:di:

It is probable that this rule should really be more general, applying in the environment of labials as well as velars:

cf. whistle → wibu

but the data are too fragmentary for a decision to be made with any confidence.

(18) /l, r, j/ are subject to the following treatment:

(a) They are neutralised as [l] where /l, r, j/ are the only consonants in the adult word, when the rule applies.

lorry → lɔli:

yellow → lɛlu:

hello → ɛlu:

(b) They become [w] or are deleted when intervocalic.

telephone → ḍɛwi:bu:n

follow → wɔwo:

corridor → g̣ɔi:ḍɔ:

The data are insufficient to determine whether the different treatment of /l/ and /r/ is random or rule-governed.

(c) They behave like the other alveolar consonants elsewhere, i.e. are neutralised as [d].

light → ḍait

write → ḍait

yes → ḍɛt

(19) Alveolar and palato-alveolar consonants harmonise to the point of articulation of a following consonant; obligatorily if that consonant is velar, optionally if it is labial.

Examples with a following velar:

dark → ġa:k	snake → ŋe:k
drink → ġik	stuck → ġʌk
leg → ġɛk	taxi → ġɛgi:
ring → ġiŋ	chocolate → ġɔgi: (from: 'chockie')
singing → ġiŋiŋ	motor-car → mu:ġǝga:

Note that the process is not limited to word-initial position, e.g. *motor-car*, and that it may give rise to words 'impossible' in English, e.g. *snake*.

Examples with a following labial:

knife → maip	room → wum
nipple → mibu	rubber → b̪ʌbǝ
stop → b̪ɔp	shopping → wɔbin
table → b̪e:bu	zebra → wi:bǝ

Note that the process applies differentially to stops (*table*, *stop*, etc.) and some continuants (*room*, *zebra*, *shopping*, etc.). The rule is optional before labials to allow for:[1]

stop → d̪ɔp (in free variation with [b̪ɔp])	
stamp → d̪ɛp	
drum → d̪ʌm	

This form of consonant harmony was very typical of A's speech, and in fact some form of consonant harmony appears to be universal.

(20) /f, v/ become [w] prevocalically.

feet → wi:t	flower → wæwǝ
finger → wiŋǝ	caravan → ˈġæwǝwæn
fire → wæ:	

Once formulated in terms of distinctive features (see below, p. 30) this rule also applies to the output of rule R19, thereby accounting for the initial [w] in:

shopping → wɔbin	room → wum
zebra → wi:bǝ	driving → waibin

[1] It may be obligatory if the consonant is a nasal, but the number of examples is too small to be certain.

(21) Post-consonantal alveolar consonants are deleted.

empty → ɛbi:
taxi → ġɛgi:
mixer → migǝ

There are not many words with consonant clusters left by this stage of the rules; but clusters of two obstruents have not been simplified as yet, and this rule performs this function.

(22) Alveolar consonants are optionally deleted in final position.

broken → b̪ugu:	moon → mu:
carpet → ġa:bi	open → ubu:
cupboard → ġʌbǝ	telephone → d̪ewi:bu:

The rule is optional to allow for such examples as:

moon → mu:n	(in free variation with [mu:])
telephone → d̪ewi:bu:n	(in free variation with [d̪ewi:bu:])
head → ɛt	etc.

(23) All alveolar and palato-alveolar consonants fall together as alveolars. That is, /ʃ, ʒ,[1] tʃ, dʒ, j, r/ are neutralised as (ultimately) |d| – with allophones [t], [d], [d̪].

brush → b̪ʌt	yes → d̪ɛt
church → d̪ǝ:t	write → d̪ait
John → d̪ɔn	

(24) All non-sonorant consonants are non-continuant, non-strident, non-affricated and non-lateral. This neutralises the affricates /tʃ, dʒ/, the stridents /f, v, s, z, ʃ, ʒ, tʃ, dʒ/ and the non-sonorant continuants /f, v, θ, ð, s, z, ʃ, ʒ/ as |d| or, in the case of /f/ in non-initial position, as |b| – with allophones [p], [b], [b̪].

bus → b̪ʌt	John → d̪ɔn
brush → b̪ʌt	bath → b̪a:t
zoo → d̪u:	other → ʌdǝ
church → d̪ǝ:t	knife → maip

(25) All consonants are voiced.

teddy → d̪ɛdi:	kiss → ġik
Daddy → d̪ɛdi:	sock → ġɔk
drink → ġik	lock → ġɔk

[1] No examples occurred at this stage, but cf. *garage* → [ġæǝd] from stage 9.

This rule gets rid of the adult voicing contrast, and every word which contains a voiceless consonant in ESP is affected. It should be noted that this rule refers to the child's system; it does NOT affect the phonetic rule which gives the allophonic differences between [d] and [ḍ] or [ġ] and [k] above, and which is discussed in 2.2.1 below.

(26) All non-vowels are true consonants.

This rule eliminates the difference between consonants and glides for A. In his system, as described below, there is no crucial difference between these two categories. The motivation for this rule becomes clearer when we see the consonantal behaviour of /w/ for A at later stages (see below, p. 107), but note already that [v] and [w] are in free variation for A, and that ESP /v/ usually corresponds to his |w|.

2.1.2 Formal statement of the realisation rules. The realisation rules listed and exemplified above can be formalised as follows. The same numbering is retained.

(1) $[+\text{nasal}]^1 \rightarrow \emptyset / \underline{\qquad} [-\text{voiced}]$

R1 must precede R21 and R25.

R1 must precede R21 as the latter also acts to simplify consonant clusters, but deletes the second rather than the first. R1 deletes the nasal in, e.g., *tent* → [dɛt], whereas if R21 preceded, *tent* would become [dɛn].

R1 must precede R25 as the latter neutralises the voicing distinction essential to the correct statement of the environment of R1. Were R25 to precede R1 there would be no means of distinguishing *mend* and *meant* for instance.

(2) $[+\text{cons}] \rightarrow \emptyset / [+\text{nasal}] \overline{[+\text{voiced}]}$

R2 must precede R3 and R25.

The justification for making R2 precede R3 is slight. At this stage it means that R3 can be more simply formulated, i.e. it refers merely to one segment rather than a sequence. However, by the next stage R2 has been modified so that it no longer operates intervocalically, with the result that R3 has to be complicated anyway (cf. the development of R2 and R3 in 3.1 p. 54 below).

R2 must precede R25 for the same reason as must R1.

[1] See Appendix B for the matrix of distinctive features presupposed for the adult consonant system which is the input to these rules.

It would be possible to conflate R1 and R2 as:

$$[+\text{cons}] \rightarrow \emptyset / \begin{cases} \overline{[+\text{nasal}]} \ [-\text{voiced}] \\ [+\text{nasal}] \ \overline{[+\text{voiced}]} \end{cases}$$

but this still fails to capture adequately the generalisation that nasal clusters are simplified differentially according to the voicing of the non-nasal segment; and the saving of one $\emptyset$ is not particularly exciting.[1]

(3) $\begin{bmatrix} +\text{coronal} \\ -\text{del rel} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{coronal} \\ -\text{anterior} \end{bmatrix} / \underline{\qquad} \left(\begin{bmatrix} +\text{syllabic} \\ -\text{stress} \end{bmatrix} \right) [+\text{lateral}]$

It is clear that R3, as formulated here, misses the generalisation that the 'velarisation' of coronals takes place before a velarised (dark) [ł]. There are various ways of expressing this, but none seems entirely satisfactory. For instance, if we use the redundant features [+high, +back] as an additional characterisation of the (usually syllabic) /l/, we can then express the change as:

$$\begin{bmatrix} +\text{cor} \\ -\text{d.r.} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{high} \\ +\text{back} \end{bmatrix}$$

i.e. an assimilation rule, and then let marking conventions convert the coronals to velars (see Chomsky and Halle, 1968, p. 429, n. 15, for a comparable instance). The trouble with this alternative is that the rule needs a more complex environment and that even its structural change is no simpler, as we have to use the two features [high] and [back] in place of the two features [coronal] and [anterior], and still invoke a series of linking conventions. The position would be improved if our evaluation metric was somewhat more sophisticated such that a change of a feature to the same feature in its environment was less costly than a change to an unrelated feature,[2] i.e. if:

$$[+\text{cor}] \rightarrow \begin{bmatrix} +\text{high} \\ +\text{back} \end{bmatrix} / \underline{\qquad} \begin{bmatrix} +\text{lateral} \\ +\text{high} \\ +\text{back} \end{bmatrix}$$

were less complex than:

$$[+\text{cor}] \rightarrow \begin{bmatrix} -\text{cor} \\ -\text{ant} \end{bmatrix} / \underline{\qquad} \begin{bmatrix} +\text{lateral} \\ +\text{high} \\ +\text{back} \end{bmatrix}$$

[1] The merit of the conflation is that it does allow the collapsing of two rules which are part of a 'conspiracy' to reduce clusters. On the other hand it makes use of the suspect device of disjunctive brackets. For discussion of both these points, see 5.3.

[2] At present this is the case only if there are two such changes, such that the *a* notation can be used to abbreviate the possibilities. This is clearly not feasible here.

leaving aside the problem of the redundancy of the environmental features. An alternative convention, which in this case would have the same result, would be to evaluate as less costly a change involving features relatively low in a feature hierarchy, i.e. here [high] and [back] are presumably lower in the hierarchy and hence more likely to change than [coronal] and [anterior] (see Smith, 1969, p. 406, for comparable suggestions on evaluation).

A further difficulty is that, in general, it is not the case that the marking conventions link into A's realisation rules. (For a brief discussion of this, see 5.3.1 below.)

R3 must precede R6, R7, R19 and R24.

R3 must precede R6 as the latter removes /l/ in final position, a segment which is necessary for stating the environment of R3.

The justification for making R3 precede R7 came in fact at a much later stage but may be adduced now. With words such as *pistol* where there is a sequence /st/ rather than a single segment in the environment before /(ə)l/, the child's form turns up with an alveolar not a velar – [pitəl] – in other words, /st/ is treated like /s/ not /t/.[1] If the /s/ were deleted by R7 before the operation of R3 there would be no means of capturing this fact.

R3 must precede R19 as the assimilation exhibited in this latter rule may operate to a velar segment produced by R3. For instance, the word *noddle* turns up as [ŋɔgu], where the [g] has arisen as a result of R3, and the /n/ has become [ŋ] as a result of R19.

R3 must precede R24 as the latter rule neutralises the distinction between segments with delayed release and those with non-delayed release, a crucial part of the structural description of the rule.

$$(4) \quad [+\text{syllabic}] \rightarrow \begin{bmatrix} +\text{high} \\ +\text{back} \\ -\text{tense} \end{bmatrix} / [\overline{-\text{stress}}] \, [+\text{lateral}] \, \#$$

Contrary to the informal description of this rule on p. 15, this formalisation turns a schwa to [u] before a final /l/. The justification for this is the manner of the disappearance of this rule, where the two segments were treated differently, e.g. *apple* was first [ɛbu], then [æbul] with [u] not [ə], and only later was it [æpəl] with [ə]. At this stage the earlier characterisation in terms of syllabic [l̩] would have been sufficient.

R4 must precede R6 and R18.

[1] This was generally the case with A; see below, p. 60.

R4 must precede R6 for the same reason as must R3.

R4 must precede R18, specifically part (c) of R18, as the latter neutralises the /d – l/ distinction in certain environments. (It should be observed that the need for R4 to precede R18 is marginal, as R6 would in any case remove all such occurrences of /l/ before R18 could apply.)

$$(5) \quad \begin{bmatrix} +\text{coronal} \\ +\text{continuant} \end{bmatrix} \underset{\text{opt}}{\rightarrow} [+\text{nasal}]/[+\text{nasal}] \, [+\text{syllabic}] \text{———}$$

R5 must precede R6 and R24.

R5 must precede R6 as the coronal continuant which is turned optionally into a nasal, may begin as a lateral which would otherwise be removed by R6.

R5 must precede R24 because the latter neutralises the continuant/non-continuant distinction crucial to the statement of the former.

$$(6) \quad [+\text{lateral}] \rightarrow \emptyset/\text{———} \begin{Bmatrix} \# \\ [+\text{consonantal}] \end{Bmatrix}$$

R6 must precede R17, R18 and R24.

R6 must precede R17 as final /l/ is always deleted and does not harmonise with a preceding labial or velar in the way the other coronals do.

R6 must precede R18 and R24 as, together, these two latter rules eliminate the distinction between /l/ and the other coronals in favour of [d], which is non-sonorant and non-lateral.

$$(7) \quad \begin{bmatrix} +\text{coronal} \\ +\text{anterior} \\ +\text{continuant} \\ +\text{strident} \\ -\text{voiced} \end{bmatrix} \rightarrow \emptyset/\text{———}[-\text{syllabic}]$$

The specifications [−voiced] and [+anterior] are probably redundant, as there were no examples of pre-consonantal /z/ or /ʃ/ in the data. The specification of the environment as [−syllabic] rather than [+consonantal] is made to include /w/ in the purview of the rule (/j/ became a problem later; see below, p. 58).

R7 must precede R8, R16, R21, R24 and possibly R23 and R25.

R7 must precede R8 because of the differential treatment of /sw/ and /Cw/ clusters (where C is any consonant other than /s/); see the remarks on p. 16 above.

R7 must precede R16 for an analogous reason; namely, the differential treatment of /s/ plus sonorant and /C/ plus sonorant clusters.

R7 must precede R21 for the same reason as must R1.

R7 must precede R24 because the latter neutralises the continuant/non-continuant and strident/non-strident distinctions crucial for stating the former.

If preconsonantal /z/ or /ʃ/ occurred in the adult forms that A re-interpreted, and if such forms were treated differently to preconsonantal /s/, then R7 would have to precede R23 and R25. There is no evidence.

$$(8) \quad [+\text{consonantal}] \to \begin{bmatrix} -\text{coronal} \\ +\text{anterior} \end{bmatrix} / [+\text{cons}] \begin{bmatrix} -\text{cons} \\ +\text{ant} \end{bmatrix} [+\text{syll}]\underline{\quad}$$

R8 must precede R16 and R17.

R8 must precede R16 as the latter deletes, *inter alia*, post-consonantal /w/ which is the crucial part of the environment of R8.

R8 must precede R17 to account for the change of, e.g., *quite* to [kaip] rather than *[kaik].

$$(9) \quad \begin{bmatrix} +\text{coronal} \\ +\text{continuant} \\ +\text{strident} \\ +\text{anterior} \end{bmatrix} \underset{\text{opt}}{\to} \emptyset / \# \underline{\quad} [+\text{syllabic}] [+\text{anterior}]$$

R9 must precede R19, R23 and R24.

R9 must precede R19 to prevent the harmonisation of the initial /s/ to [b̪] in examples such as *soup* (→ [u:p]).

R9 must precede R23 as the latter neutralises the distinction between anterior and non-anterior consonants, a distinction which is essential for the operation of this and the following rule.

R9 must precede R24 because the latter neutralises the continuant/non-continuant and strident/non-strident distinctions crucial to the statement of the former.

$$(10) \quad \begin{bmatrix} +\text{coronal} \\ +\text{continuant} \\ +\text{strident} \\ -\text{anterior} \end{bmatrix} \underset{\text{opt}}{\to} \emptyset / \# \underline{\quad} [+\text{syllabic}] [-\text{coronal}]$$

R10 must precede the same rules, R19, R23 and R24, as must R9.

R10 must precede R19 to prevent the harmonisation of initial /ʃ/ to [b̪] or [ġ] in words such as *sharp* (→ [a:p]) and *sugar* (→ [ugə]).

R10 must precede R23 and R24 for the same reasons as must R9.

$$(11) \quad \begin{bmatrix} +\text{coronal} \\ +\text{continuant} \\ +\text{strident} \\ +\text{anterior} \\ +\text{voiced} \end{bmatrix} \to \emptyset / \underline{\quad} \#$$

R11 must precede R17, R24 and R25.

R11 must precede R17 to prevent the final /z/ in forms such as *goes* from harmonising to the initial consonant.

R11 must precede R24 as the latter neutralises the continuant/non-continuant, strident/non-strident and delayed release/non-delayed release contrasts, and final /z/ is treated differently from final /d/, /ð/ and /dʒ/.

R11 must precede R25 as the latter neutralises the adult voicing contrast, and final /z/ and /s/ are treated differently.

$$(12) \quad [+\text{nasal}] \to \begin{bmatrix} +\text{coronal} \\ +\text{anterior} \end{bmatrix} / X \begin{bmatrix} +\text{syllabic} \\ -\text{stress} \end{bmatrix} \underline{\quad}$$
where X ≠ /ŋ/

R12 must precede R19 as otherwise a stem final coronal consonant followed by an /iŋ/ suffix[1] would itself become velar, whereas it in fact retains its coronality.

$$(13) \quad \begin{bmatrix} -\text{syllabic} \\ -\text{consonantal} \\ -\text{sonorant} \end{bmatrix} \to \emptyset$$

R13 must precede R18, specifically part (a) of R18, as the presence of an initial /h/ in the adult form does not prevent the appearance of an [l] in the child's form: cf., e.g., *hello* → [ɛlu:], and note the remarks on MS2 below, p. 48. It would be possible to order R13 after R18 if we complicated the environment of the latter. This would then enable us to group all context-free realisation rules in a block; cf. the discussion in section 4.3.6.

$$(14) \quad [+\text{syllabic}] \to \emptyset / \# (C) \overline{[-\text{stress}]} C \begin{bmatrix} +\text{syllabic} \\ +\text{stress} \end{bmatrix}$$

R14 must precede R16 *or* R21.

R14 must precede R16 as the deletion of an unstressed interconsonantal vowel may give rise to a cluster which is then simplified by the latter rule, e.g. *banana* → [b̪a:nə] discussed on p. 18 above. We should in

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[1] In fact, as mentioned on p. 18, the /iŋ/ need not be a separate morpheme.

fact get the correct result even if R14 did not precede R16 as long as it preceded R21. I have made it precede R16 on the slender basis of my intuition that *belong* and *banana* ([b̥ɔŋ] and [b̥a:nə]) are the result of the same process, and that *belong* loses its /l/ by the same rule which gives us [b̥u:] from *blue*. There is some evidence for the latter in that *belong* became [blɔŋ] as soon as other [Cl] clusters appeared. Unfortunately the treatment by A of words containing unstressed initial syllables was inconsistent; cf. the following examples taken from various stages:

tomato	→ ma:du:	behind	→ aind
potato	→ b̥e:du:	without	→ aut
pyjamas	→ d̥a:mə	etc.	

The last two may be explicable in terms of their internal structure, but the pair *potato* and *pyjamas* seems to indicate that it is impossible to make a generally valid statement (see 4.3.4. below).

$$(15) \quad \begin{bmatrix} +\text{coronal} \\ +\text{anterior} \\ -\text{continuant} \end{bmatrix} \underset{\text{opt}}{\rightarrow} \emptyset / \# \text{------} \begin{bmatrix} +\text{coronal} \\ +\text{continuant} \end{bmatrix}$$

The environment [+coronal, +continuant] in fact refers to /l, r, j, s, z, θ, ð, ʃ, ʒ/, but non-sonorants and /l/ do not occur in this position in English; and /j/ did not occur in the data.

R15 must precede R16, R21 and R24.

R15 must precede R16, as otherwise /dr/ clusters of this exceptional type would be reduced to [d] rather than [r]. As R15 is optional and R15 and R16 together cover all cases of consonant plus sonorant clusters, it would of course be possible to order R16 first and make it optional and R15 obligatory. The sequence given has been chosen because R16 expresses the regular situation, R15 the exceptional one.

R15 must precede R21 for the same reason as must R1.

R15 must precede R24 as the latter neutralises the distinction between continuant and non-continuant segments; a contrast needed to state the input to the former rule.

$$(16) \quad [+\text{sonorant}] \rightarrow \emptyset / [+\text{consonantal}] \text{------}$$

R16 must precede R18, specifically part (c) of R18, as the latter makes /l, r, j/, all of which may potentially occur postconsonantally, non-sonorant.

$$(17) \quad \begin{bmatrix} +\text{coronal} \\ -\text{nasal} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{coronal} \\ -\text{anterior} \end{bmatrix} / \begin{bmatrix} -\text{coronal} \\ -\text{anterior} \end{bmatrix} [+\text{syllabic}] \text{------}$$

There is no evidence to indicate that R17 should precede any other rule.[1]

$$(18) \quad \begin{bmatrix} +\text{coronal} \\ +\text{continuant} \\ +\text{sonorant} \end{bmatrix} \rightarrow \begin{cases} [+\text{lateral}] / \begin{cases} \left(\begin{bmatrix} +\text{cor} \\ +\text{cont} \\ +\text{son} \end{bmatrix}\right)[+\text{syll}]\text{------}[+\text{syll}] & \text{(a)} \\ \text{------}[+\text{syll}]\begin{bmatrix} +\text{cor} \\ +\text{cont} \\ +\text{son} \end{bmatrix}[+\text{syll}] \end{cases} \\ \begin{cases} \begin{bmatrix} -\text{cons} \\ -\text{cor} \\ +\text{ant} \end{bmatrix} \\ \emptyset \end{cases} / [+\text{syll}]\text{------}[+\text{syll}] & \text{(b)} \\ [-\text{son}] & \text{(c)} \end{cases}$$

The subparts of this rule are <u>disjunctively ordered</u>.

R18 must precede R19 and R24.

R18 must precede R19 so that the coronal /l/ in words such as *like* can be made non-sonorant before it is made non-coronal by R19.

R18 must precede R24 as the latter operates on the output of part (c). That is an /l, r, j/ which is not retained as [l], converted to [w], or deleted by R18(a, b), becomes non-sonorant by R18(c) and then becomes non-continuant and non-lateral (i.e. [d]) by R24 (see the examples on p. 19 above).

$$(19) \quad [+\text{coronal}] \rightarrow \begin{bmatrix} -\text{coronal} \\ \alpha\text{anterior} \end{bmatrix} / \text{------}[+\text{syllabic}]\begin{bmatrix} -\text{coronal} \\ \alpha\text{anterior} \end{bmatrix}$$

Originally this rule was probably more general, with the input simply specified as [+consonantal].[2] This is indicated by various 'remnant' forms such as:

Cooper	→ pu:pə
Grandpa	→ b̥ʌbʌ

That the harmony was never quite complete is shown by the nonce early form [d̥ɔk] for *sock* which, by stage 1, was invariably [g̊ɔk].

R19 must precede R20 so that the latter can convert to [w] not only the adult /f, v/, i.e. [−coronal, +anterior] segments, but also those segments, such as an original /z, ʃ, r/ which are made [+anterior] by the

---

[1] But cf. the discussion on rule ordering in 4.2.2.

[2] The fact that in the present system (i.e. Chomsky and Halle, 1968) it is *not* more simple is an anomaly I have indicated before; see p. 24 above.

operation of R19. (See the examples on p. 20 above, and the derivations in 2.1.3 below.)

$$(20) \quad \begin{bmatrix} -\text{coronal} \\ +\text{anterior} \\ +\text{continuant} \\ -\text{lateral} \end{bmatrix} \rightarrow [+\text{sonorant}]/\underline{\quad\quad}[+\text{syllabic}]$$

The somewhat unexpected feature [−lateral] is to exclude /l/ from the set of items which harmonise to [w] before labials. That is, we have:

room → wum
Robbie → wɔbiː
but: slipper → b̥ibə   *wibə

There was, in fact, one exception: *rubber-band* → [b̥ʌbəbæn] instead of the expected *[wʌbəbæn]. This was probably a remnant form from a period of more general consonant harmony, but data are too scarce to be sure.

The feature [+sonorant] is used rather than the more likely [−consonantal] because of the apparently consonantal status of [w] in A's own speech. (See below, p. 46, and R26.)

R20 must precede R24 as the latter neutralises the continuant/non-continuant distinction crucial for the former.

$$(21) \quad [+\text{coronal}] \rightarrow \emptyset/[+\text{consonantal}]\underline{\quad\quad}$$

$$(22) \quad [+\text{coronal}] \underset{\text{opt}}{\rightarrow} \emptyset/\underline{\quad\quad}\#$$

Were it not for the optionality of R22 these two rules could be conflated, though the saving effect would be minimal.

$$(23) \quad [+\text{coronal}] \rightarrow [+\text{anterior}]$$

Note that this rule is equivalent to MS8 (see below, p. 50).

$$(24) \quad [-\text{sonorant}] \rightarrow \begin{bmatrix} -\text{del rel} \\ -\text{strident} \\ -\text{continuant} \\ -\text{lateral} \end{bmatrix}$$

We need the specification [−sonorant], rather than [−syllabic], so that those occurrences of /l, r, j/ which were made [−sonorant] by

R18(c) fall together with |d|, whereas those occurrences of /l/ and /w/ which survive, or are created by R20, retain their status.

$$(25) \quad [+\text{segment}] \rightarrow [+\text{voiced}]$$

$$(26) \quad [-\text{syllabic}] \rightarrow [+\text{consonantal}][1]$$

For a tabular display of all the ordering relations, see 4.2.2 below; and for a discussion of the implications of the formal differences between the last few rules and all the preceding ones, see 4.3.6.

2.1.3 Derivations exemplifying the realisation rules. Having enumerated the realisation rules above, I will now further illustrate their working by giving a number of derivations showing mappings from ESP to A's phonological system. It should be noted throughout that vowel changes and allophonic or free variation accounted for by A's phonetic rules (see 2.2.4 below) are left unexplained. The form of the derivations is given as follows. The first line has the relevant example in orthography, followed by a phonetic representation of A's pronunciation of it, and a phonemic representation of it in terms of his system. The next line starts with the word in ESP phonemic transcription and relates this by an arrow to an intermediate form, to the right of which occurs (in parentheses) the number of the realisation rule which effects the change. Succeeding lines take the right hand side of the preceding line as input, and show the effect of further rules upon it. The derivation continues until no more rules can apply; i.e. their structural description is not satisfied by the form in question, or we have reached the end of the rules. It should be observed that the stages intermediate between the adult phonemic representation in /.../ and the child's phonemic representation in |...| have no theoretical status. It may even be the case that the intermediate form can only be represented by means of an (unpronounceable) matrix of distinctive features (see (ii) below).

(i) *snake*	[ŋeːk]	|ŋeːg|
/sneik/	→ neik	(7)
neik	→ ŋeik	(19)
ŋeik	→ ŋeig	(25)[2]

[1] 'True consonants' (see p. 22) thus means: [−syllabic, +consonantal]. Note that this definition is not co-extensive with that in Chomsky and Halle, 1968.
[2] Rules which apply vacuously are not specified, e.g. R26 in each derivation.

(ii) *like* [g̈aik] |gaig|

$$/laik/ \rightarrow \begin{bmatrix} l \\ -son \end{bmatrix} aik \quad (18c)$$

$$\begin{bmatrix} l \\ -son \end{bmatrix} aik \rightarrow \begin{bmatrix} -cor \\ -ant \\ -son \\ \cdot \\ \cdot \end{bmatrix} aik \quad (19)$$

$$\begin{bmatrix} -cor \\ -ant \\ -son \\ \cdot \\ \cdot \end{bmatrix} aik \rightarrow \begin{bmatrix} -cor \\ -ant \\ -son \\ -del\ rel \\ -cont \\ -lateral \end{bmatrix} aik \quad (24)\ i.e.\ gaik$$

gaik → gaig (25)

(iii) *stamp* [d̈ep] |dɛb|

/stæmp/ → stæp (1)
stæp → tæp (7)
tæp → tæp (19) fails to apply – note that
                                         it is optional if $\alpha = +$
tæp → dæb (25)

(iv) *knife* [maip] |maib|

/naif/ → maif (19)
maif → maip (24)[1]
maip → maib (25)

(v) *handle* [ɛŋu] |ɛŋu|

/hændəl/ → hænəl (2)
hænəl → hænəl (3)
hænəl → hæŋul (4)
hæŋul → hæŋu (6)
hæŋu → æŋu (13)

(vi) *driving* [waibin] |waibin|

/draiviŋ/ → draivin (12)
draivin → raivin (15)

---

[1] The change from a labio-dental to a bilabial articulation is assumed.

$$raivin \rightarrow \begin{bmatrix} r \\ -son \end{bmatrix} aivin \quad (18)$$

$$\begin{bmatrix} r \\ -son \end{bmatrix} aivin \rightarrow \begin{bmatrix} -son \\ -cor \\ +ant \end{bmatrix} aivin \quad (19)$$

$$\begin{bmatrix} -son \\ -cor \\ +ant \end{bmatrix} aivin \rightarrow \begin{bmatrix} +son \\ -cor \\ +ant \end{bmatrix} aivin \quad (20)\ i.e.\ waivin$$

waivin → waibin (24)

Note that the rules as formulated make the counter-intuitive claim that /r/ goes from [+sonorant] to [−sonorant] to [+sonorant]. This is clearly farcical; even if there are precedents in the literature (cf. the treatment of the underlined vowel in *tabular*, [tæbjələ] in Chomsky and Halle, 1968, p. 197, which is inserted by rule as a lax *u*; is tensed and unrounded by a second rule, and is then made lax and reduced by a third rule!) and is probably an indication that the child is really operating in terms of segments of a phonemic nature rather than a featural nature, and that the rules are to that extent inadequate (see below, p. 189, for some discussion).

(vii) *milk* [mik] |mig|

/milk/ → mik (6)
mik → mig (25)

(viii) *lorry* [lɔli:] |lɔli:|

/lɔri:/ → lɔli: (18, 23)
(R18 makes /r/ lateral; R23 makes it anterior)

(ix) *smell* [mɛn] |mɛn|

/smɛl/ → smɛn (5)
smɛn → mɛn (7)

The change of the /n/ to [−lateral] is assumed. If it were required to capture this formally, it would necessitate adding [−continuant] to R5, deleting the feature [lateral] from R24 and having a final rule: [−continuant] → [−lateral].

(x) *tweet*   [ḅi:p] |bi:b| (cf. p. 16 above)

/twi:t/	→	twi:p	(8)
twi:p	→	ti:p	(16)
ti:p	→	pi:p	(19)
pi:p	→	bi:b	(25)

(xi) *sun*   [ʌn]/[ḍʌn] |ʌn/dʌn|

(a)	/sʌn/	→	ʌn	(9) If the option is chosen.
(b)	/sʌn/	→	sʌn	(9) If the option is not chosen.
	sʌn	→	tʌn	(24)
	tʌn	→	dʌn	(25)

(xii) *sugar*   [ugə]   /ugə/

/ʃugə/	→	ugə	(10) Assuming the option is taken.

(xiii) *please*   [ḅi:] |bi:|

/pli:z/	→	pli:	(11)
pli:	→	pi:	(16)
pi:	→	bi:	(25)

(xiv) *banana*   [ḅa:nə] |ba:nə|

/bə'na:nə/	→	bna:nə	(14)
bna:nə	→	ba:nə	(16)

(xv) *cloth*   [ġɔk] |gɔg|

/klɔθ/	→	kɔθ	(16)
kɔθ	→	kɔx	(17)
kɔx	→	kɔk	(24)
kɔk	→	gɔg	(25)

(xvi) *empty*[1]   [εbi:] |εbi:|

/εmpti:/	→	εpti:	(1)
εpti:	→	εpi:	(21)
εpi:	→	εbi:	(25)

(xvii) *broken*   [ḅugu:] |bugu:|

/brəukən/	→	bəukən	(16)
bəukən	→	bəukə	(22)
bəukə	→	bəugə	(25)

[1] With the meaning 'cup'.

The vowel pattern is the manifestation of a remnant vowel harmony rule.

(xviii) *slipper*   [ḅibə] |bibə|

/slipə/	→	lipə	(7)

$$\text{lipə} \rightarrow \begin{bmatrix} 1 \\ -\text{son} \end{bmatrix} \text{ipə} \quad (18)$$

$$\begin{bmatrix} 1 \\ -\text{son} \end{bmatrix} \text{ipə} \rightarrow \begin{bmatrix} -\text{cor} \\ +\text{ant} \\ -\text{son} \\ +\text{lat} \end{bmatrix} \text{ipə} \quad (19)$$

Because of the specification [+ lateral], R20 cannot apply.

$$\begin{bmatrix} -\text{cor} \\ +\text{ant} \\ -\text{son} \\ +\text{lat} \end{bmatrix} \text{ipə} \rightarrow \begin{bmatrix} -\text{cor} \\ +\text{ant} \\ -\text{son} \\ -\text{lat} \\ -\text{cont} \end{bmatrix} \text{ipə} \quad (24) \text{ i.e. bipə}$$

bipə	→	bibə	(25)

2.1.4 Exceptions. The rules formulated and exemplified above account for about 97 per cent of A's vocabulary. There is, however, a small residue of irregular forms for which the rules make the wrong predictions. I list these here:

1. aeroplane → [ε:bəʔe:n]
2. brief-case → [ḅi:kkeit]
3. Granna → [læla:] (cf. Grandpa → [ḅʌbʌ])
4. greedy → [ġi:di:]
5. lawn-mower → [mɔ:mə]
6. little → [ḍidi:]
7. lolly → [ɔli:]
8. telephone → [ḍεwi:bu:]

I am not treating as exceptional for present purposes either: (a) words which are imitations of adult baby forms:

cat → ['mi:au]	dog → [wowo]
chocolate → [ġɔki:/ġɔgi:]	urinate → [wi:wi:]

or (b) are exceptional only in that they retain a canonical form exemplifying the vowel harmony of a yet earlier stage:

broken → [ḅugu:] (see example (xvii) above)
open → [ubu:]

Examples 3 and 6 above come partially under this rubric but have other exceptional features as well. Example 3 appears to exemplify consonant harmony conditioned by the liquid of the adult form /ˈgrænaː/. To account for [lælaː] we should have to extend R15 to non-coronals, and assume that in a word containing all sonorants the liquids were favoured. The quality of the vowel is positionally determined; see *broken* etc. above. The form *Grandpa* → [b̥ʌb̥ʌ] is analogous except that for reasons unknown the dominant consonant was the /p/, i.e. /græmpaː/ loses the /m/ by R1, the /r/ by R16, is voiced by R25 and merely requires an extension of R19 to non-coronals again to provide the child's form.[1] Example 5, *lawn-mower*, appears to be the converse of 3 with regard to the dominance or otherwise of the nasal. Example 6, *little*, is odd, and was exceptional throughout A's development (see Appendix C). Example 1, *aeroplane*, is perhaps partially regular, if we consider the metathesis rule which became productive at a later stage (see pp. 98f. below) and which would transpose /r/ and /p/. We would thus have the derivation:

/ɛərəplein/ → ɛərəpein	(16)	
ɛərəpein → ɛəpərein	(metathesis)	
ɛəpərein → ɛəpəein	(18b)	
ɛəpəein → ɛəbəein	(25)	

leaving the only irregularity the glottal stop, which is not completely unexpected in such an environment.

Example 2, *brief-case*, seems to be merely a case of irregular but not surprising assimilation. Example 7, *lolly(pop)*, I have no explanation for unless it was a subconscious avoidance of homonymic clash: *lolly* should have become [lɔliː] which was also the form assumed by *lorry* and *trolley*. However, as massive homonymy never worried A at any other time this seems an unlikely reason. Example 8, *telephone*, is irregular in having [b] instead of [w]. In fact there are too few examples to tell whether this is really regular; i.e. that rule R20 should be constrained to initial position and that *caravan* → [ˈgæwəwæn], here described as regular, is really irregular; or whether they are both regular and we should have different rules in this one position for /f/ and /v/.

[1] One other pre-stage 1 example of a comparable nature occurred: *Cooper* → [puːpə]. The voicelessness appeared to be random.

2.2 A's phonology as a self-contained system

In the first part of this chapter I set up an ordered series of realisation rules mapping adult forms of English into the (phonemic) forms that the child actually produced. In this section I want to look at the formal properties of the system that the child appeared superficially to be utilising; i.e. his output, as opposed to the system he was exposed to. The discussion in chapter 4 will show that I agree largely with Stampe (1970, p. 4) that 'no evidence whatsoever has been advanced to support this assumption [that the child has a phonemic system of his own – NVS]'; but without attempting a detailed analysis of the putative system, and viewing its properties both synchronically and diachronically, it is impossible to judge whether or not it actually does have any psychological reality for the child.

2.2.1 Informal exemplification of A's system. Restricting ourselves to the consonant system for the moment, we can describe A's phonology by reference to only eight phonemes:

$$|b \quad d \quad g \quad m \quad n \quad ŋ \quad w \quad l|$$

That is, we have a voiced plosive series: bilabial, alveolar and velar (b, d, g); a nasal series with the same points of articulation (m, n, ŋ); and two continuants: one labio-velar semi-vowel (w) and a lateral liquid (l).

It should be emphasised that the child's phonetic output is not as simple as the reduced system above might lead one to believe. Although the eight phonemes cited were the only consistently distinctive segments, they had different realisations as the result of allophonic and free variation. Thus the plosives, represented here by |b, d, g|, each had three allophones:

voiceless, unaspirated, lenis in initial position	[b̥, d̥, ġ]
voiced, unaspirated, lenis in medial position	[b, d, g]
voiceless, fortis (aspirated or unaspirated) in final position	[p, t, k]

The nasals and continuants had no obvious allophonic variants, but the latter had a number of free variants. Thus |w| was realised usually as a voiced, labio-velar frictionless continuant, [w]; but often (especially intervocalically) as a voiced labio-dental fricative, [v]; and occasionally as a voiced bilabial fricative, [β]. The lateral liquid was most usually apico-alveolar, but occasionally a laminal variant was heard; and once or twice a lengthened, quasi-syllabic variant appeared.

Although the statement of allophonic variation for the plosives above reflects the commonest situation, it was not unusual to hear the 'wrong' allophones on occasions; for instance, an initial [p, t, *or* k] or a final [ḅ, ḍ *or* ġ]. This latter was particularly common if the relevant plosive was not utterance final; e.g. [ġug nait] for *goodnight*. It is, however, quite certain that there was no controlled contrast between voiced and voiceless, aspirated or unaspirated until a much later stage (see p. 112 below).

Examples of all the consonant phonemes, followed by an illustrative word in phonetic and phonemic transcription, together with their adult equivalent in ordinary orthography, are given below:

	b		['ḅe:bu]		be:bu		table
		[ḅʌp]		bʌb		bump
	d		['ḍɛdi:]		dɛdi:		Daddy, teddy
		[a:t]		a:d		hard
	g		[ġʌk]		gʌg		truck
		[ġip]		gib		crib
		[ġə:gən]		gʌgən		curtain
	m		[mɔ:]		mɔ:		more
		[ġi:m]		gi:m		cream
	n		[nu:]		nu:		nose
		[ġɔ:nə]		gɔ:nə		corner
		[ġin]		gin		skin
	ŋ		[ŋeⁱk]		ŋe:g		snake
		[ġiŋiŋ]		giŋiŋ		singing
	w		['winu:]		winu:		window
		['ġæwəwæn]			
		['ġæwəvæn]		gɛwəwɛn		caravan
	l		['lɔli:]		lɔli:		lorry
		[ɛlu:]		ɛlu:		hello

The vowel system at this stage was both more fluid and more complex, in that A appeared to control a greater number of contrasts than he did in the consonant system, but with a much greater degree of alternation and free variation. The system was as follows:

|i: i e: ɛ æ: a: ə: ʌ ɔ o: u u:|

That is, we have close front and back vowels, which have both tense (i:, u:) and lax (i, u) congeners; half-close front and back tense vowels (e:, o:); half-open lax vowels (ɛ, ɔ, ʌ); and two tense open vowels (æ:, a:). There was also a schwa (ə) occurring in unstressed syllables only;

and two diphthongs (ai, au) and a partially controlled tense central vowel (ə:).

The relationship of these vowels to adult ESP is fairly straightforward. An enumeration of the correspondences exemplifying each of A's vowels follows:

	i:	corresponds to adult /i:/	[wi:t]	= feet
	i	corresponds to adult /i/	[ġiŋ]	= ring
	e:	corresponds to adult /ei/	[de:n]	= rain

There was frequently a diphthongal offglide to this segment, thus: [eⁱ]; but the onset was consistently closer than ESP.

	ɛ	corresponds to adult /e/	[ḅɛn]	= pen
	/æ/	[mɛn]	= man (*and* 'men')
	/ɛə/	[dɛ]	= chair
	æ:	corresponds to adult /aiə/	[wæ:]	= fire

In my speech /aiə/ is frequently monophthongal.

| |a:| corresponds to adult /a:/ | [a:t] | = hard |
| |ə:| corresponds to adult /ə:/ | [wə:gin] | = working |

It is hard to be certain whether |ə:| was distinct from |a:| on the one hand and |ʌ| on the other. Phonetically all occurred, but there was probably only a two-way contrast phonemically.

| |ʌ| corresponds to adult /ʌ/ | [ḅʌt] | = brush |
| |ɔ| corresponds to adult /ɔ/ | [ġɔk] | = cloth |

This was only intermittently distinct from |ʌ|.

	o:	corresponds to adult /ɔ:/	[mo:]	= more
	/oi/	[no:ni:]	= noisy
	u	corresponds to adult /u/	[wut]	= foot
	[l]	[ḅɔgu]	= bottle
	u:	corresponds to adult /u:/	[ġu:]	= screw
	/əu/	[u:p]	= soap *and* soup
	ai	corresponds to adult /ai/	[dait]	= light
	au	corresponds to adult /au/	[ḍaun]	= down

On occasions |ai| and |au| lost the offglide and fell together with |æ:|. There was one occurrence of [ɔi]: *boy* → [ḅɔi], although elsewhere /oi/ was treated as |o:|, and later as a sequence |o: i:|. No examples of /iə/ or

/uə/ were recorded at this stage, but they too were later treated as either sequences:

beard → ḅi:a:t
ear → i:ə

or were reduced to the first element:

poor → ḅu (/puə/ in my speech).

With the exception of isolated comments of relevance to the consonantal system, I will have little more to say about A's vowels.

2.2.2 Informal statement of morpheme structure conditions.

In addition to an inventory of segments, it is obviously also necessary to state the restrictions on the co-occurrence of these segments. In other words we want to know that |gi:m| (*cream*) is a possible morpheme for A, whilst *|gli:m| is not; that |ŋ| can occur initially in A's speech even though it cannot in ESP, but that it only occurs word finally if the final syllable of the word is stressed, and so on. The following conditions list all such restrictions for which there is sufficient evidence to make fairly rigorous statements.

(1) All morphemes[1] are of the form:

$$(C) \ V \ (V) \ (C(V(C(V(C)))))$$

where C is a consonant and V is a vowel, and parentheses indicate optionality. That is, every morpheme must contain a vowel which may be preceded by at most one consonant, and may be followed by another vowel or an alternating sequence of consonants and vowels up to a maximum of three syllables. Thus we have:

V	ɛ	(hair)	CVCV	ḅɔgu	(bottle)
CV	ḅu:	(blow)	CVCVC	ḅɔdin	(bottom)
CVC	ḅa:t	(bath)	CVCVCV	ḅʌdəwai	(butterfly)
VC	æt	(ant)	CVCVCVC	ḍɛwi:bu:n	(telephone)

The optional vowel (V) is inserted for the sake of a mere two or three examples of the type: CVVCV [ġɔi:do:] (corridor) – which was tri-syllabic – but this possibility was not really established until a little later. In other words, we can say essentially that A's vocabulary contains words built on a strictly alternating sequence of consonants and vowels.

[1] As the vast majority of A's words are monomorphemic at this stage, and even where polymorphemic fail to give rise to exceptions to this canonical form, we could use *word* just as well here.

(2) Within a word all consonants must be |l| or none must be |l|. That is, we have a form of consonant harmony which allows such possibilities as:

lɔli:	(lorry)	lɔlə	(troddler)
ɛlu:	(hello)	ɔli:	(lolly)
læla:	(Lalla – a name)		

where all the consonants are |l|; but which excludes such possibilities as ESP |lait| (→ [ḍait]), /laik/ (→ [ġaik]), /bɔ:l/ (→ [ḅɔ:]), etc.

(3) |w| and |l| may not occur word finally. That is, whereas the plosives and nasals are relatively unrestricted in their privileges of occurrence, the two continuants are restricted to initial and medial position. In the case of |w| this is a restriction parallel to one for /w/ in the adult language;[1] in the case of |l| it is a peculiarity of A's own system.

(4) Within a word an alveolar consonant may not precede a velar consonant. Given that we have no consonant clusters, 'precede' here means 'precede with an intervening vowel'. In other words, in a morpheme of the structure: $|C_1VC_2VC_3\ldots|$ C_1 cannot be an alveolar, |d, l, n| if C_2 is a velar, |g, ŋ|; C_2 cannot be an alveolar if C_3 is a velar, and so on. That is, we have examples such as:

ġɔk	(cock)	mik	(milk)
ḅɛk	(back)	wɔ:k	(walk)
ŋeik	(snake)		

but nothing like ESP:

/laik/ → ġaik
/dʌk/ → ġʌk
/nɛk/ → ŋɛk   etc.

Examples of this constraint operating between C_2 and C_3 are limited (the number of polysyllabic items in A's vocabulary was not great), but a typical one is:

mu:gəga: (motor-car)

In fact the converse of this condition also operated if we exclude nasals from the account. That is, within a word a non-nasal alveolar consonant may not follow a velar consonant. Clearly, as we have already excluded

[1] But note that |w| is A's reflex of several other ESP consonants (e.g. some occurrences of /f/), so it cannot be assumed that the constraints will necessarily be the same. Cf. p. 107 below, where the constraint is in fact lifted.

|l| from cooccurring with any other consonant, we are really saying that |d| may not follow a velar. Accordingly we have:

ġɔ:nə   (corner)
ġin   (skin)

but nothing comparable to the adult /gud/ (→ [ġug]), /kə:tən/ (→ [ġə:gən]) /kəutʃ/ (→ [ġo:k]), etc.

There was one exception to this condition, namely:

ġi:di: (greedy)

It should, perhaps, be mentioned that at an earlier stage, the condition was more general, and prohibited alveolars from occurring with labials as well. See, for example, the somewhat conservative form:

ḅe:bu   (table)

and the free variation between [ḅɔp] and [ḍɔp] for *stop*.

(5) Within a word an alveolar nasal |n| may precede only other alveolar consonants; alternatively, it may not precede labials or velars. That is, we have such examples as:

nait   (nice)
nɔ:ni: (noisy)

but there is nothing comparable to the adult /naif/ (→ [maip]), /sneik/ (→ [ŋeik]), /nipəl/ (→ [mibu]) and so on.

The converse of this condition does not apply. We do find examples such as:

mu:n   (moon)
winu: (window) etc.

(6) The velar nasal |ŋ| may precede only another velar segment |ŋ, g|. Thus we have:

ŋeik   (snake)
ŋʌŋgə   (nanga[1])

but nothing like: *[ŋe:p] or *[ŋu:t].

(7) Of the nasal consonants |m, n, ŋ| only the alveolar nasal |n| can occur in an unstressed syllable. The only exception to this is that a velar

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[1] This example is taken from the next stage, and is A's attempt at an anglicised version of the Hindi [nəŋgə] – *naked*. It is included merely to indicate that the gap of |ŋ – ŋ| is fortuitous in a way that the gap |ŋ – m| is not fortuitous: viz. A knew no adult word of ESP of the form /n – ŋ/.

nasal |ŋ| may occur in this position provided that the preceding consonant is itself |ŋ|. Thus we have:

ġigən   (kitchen)
ġiŋiŋ   (singing)

but nothing comparable to the adult /bɔtəm/ (→ [ḅɔdin]), /rʌniŋ/ (→ [dʌnin]), /teikiŋ/ (→ [ġeigin]) and so on.

There are probably other conditions statable; this is certainly the case as regards vowels, for instance, but those above give a reasonably complete statement of the restrictions on A's idiolect.

With eight consonants, and taking the most common canonical forms, |CVC| and |CVCV| (accounting for 146 out of 225 words recorded vocabulary at this stage; i.e. 65 per cent) one should expect 128 (= $8^2 \times 2$) consonantal combinations in a totally unconstrained system; whereas in fact we only get 49; while 58 are excluded and we have 21 random gaps.[1] Of these 49 combinations many occur more than once, either as homophones: thus [ġʌk] (= |gʌg|) means all of *duck, stuck, jug, rug, luck, truck*, etc. or with different vowels; e.g. both [wæwə] – *flower* and [wɔwo:] – *follow* are examples of |wVwV|. Table 1 displays all the recorded occurrences.

The vertical axis C_1 shows the initial consonant in |CVC(V)| structures. The horizontal axis C_2 shows the second consonant in |CVC(V)| structures. Each square is potentially divided into two triangles: the top left representing a |CVC| form, the bottom right a |CVCV| form. A tick, ✓, indicates that the relevant form occurs and is exemplified below; a number, 2, 3, 4, 5 or 6, indicates that the form does not occur and is excluded by the MS condition numbered; a gap indicates that the relevant form does not occur, but is not excluded by any MS condition, and is accordingly viewed as random.

Thus if we take the top row where the initial consonant (C_1) is |b|, we see that the forms: |bVb, bVbV, bVd, bVdV, bVg, bVgV, bVn and bVnV| all occur; that |bVm, bVmV, bVŋ, and bVŋV| are all random

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[1] A gap is deemed 'random' and therefore not to be accounted for by MS conditions if it satisfies the following two criteria:
  (i) There was no realisation rule precluding its occurrence.
  (ii) The gap was filled at a subsequent stage, and at a stage still otherwise characterised by the same MS conditions; e.g. |b – ŋ| does not occur at stage 1, but at stage 2 [bæŋ] – *bang* appeared.

If we took merely |CVC| forms the number of gaps would decrease to only five. It should be noted incidentally, that all these conditions generalise to other canonical forms as well. The two types |CVC| and |CVCV| have only been taken for exemplificatory purposes and because they constitute the majority of examples.

TABLE I. *All recorded instances of consonantal combinations at stage 1*

C₁ \ C₂	b	d	g	m	n	ŋ	w	l
b	✓/✓	✓/✓	✓/✓	✓	✓		3/✓	2
d	✓/✓	✓/✓	4	✓/✓	✓	4	3	2
g	✓/✓	(4)	✓/✓	✓/✓	✓	✓	3	2
m	✓/✓	✓/✓	✓	✓	✓		3	2
n	5	✓/✓	4	5	✓	4	3/5	2
ŋ	6	6	✓	6	6		3/6	2
w	✓/✓	✓/✓	✓/✓	✓/✓	✓	✓	3	2
l	2	2	2	2	2	2	2	3/✓

gaps; that |bVw| is excluded by MS3 whereas |bVwV| occurs, and that both |bVl| and |bVlV| are excluded by MS2.

Some possibilities: e.g. |ŋVl| would be excluded by several conditions (2, 3, 6), but only the most general is given. The parentheses around |gVd| and |gVdV| are to indicate that MS4 excludes both, but that |gVdV|, exceptionally, occurs.

All items occurring are exemplified below, working from left to right and top to bottom. The examples are given in phonetic transcription, so it must be remembered that the first item, for instance, while phonetically [bə:p], is phonemically |bə:b|. The list is exhaustive of the CVC(V) canonical forms found, but obviously not of the data as a whole. The totality of the data at stage 1 is reconstructible from Appendix C.

ḅə:p	burp	ḅɛdə	better
ḅẹibi:	baby	ḅuk	book
ḅa:t	bath	ḅugu:	broken

ḅə:n	burn	mait	mice
ḅa:nə	banana	mik	milk
(¹wi:bæwu:	wheel-barrow)¹	migə	mixer
ḍæp	stamp	mɔ:mə	lawn-mower
ḍə:t	shirt	mɛn	mend
ḍidə	scissors	nait	nice
ḍʌm	drum	nɔ:di	naughty
ḍɔn	John	nɔ:ni:	noisy
(ḍʌnin	running)¹	ŋeik	snake
ġip	crib	wɔp	shop
ġʌbə	cupboard	wi:bə	zebra
ġi:di	greedy	wɔt	wash
ġɔk	cloth	wɔ:k	fork
ġa:gi:	glasses	(wə:gin	working)¹
ġi:m	cream	wum	room
ġi:n	clean	wʌn	one
ġɔ:nə	corner	winu:	window
ġʌŋ	tongue	wiŋ	swing
(ġiŋiŋ	singing)¹	wiŋə	finger
(¹ġæwəwæn	caravan)¹	wɔwu:	follow
maip	knife	lɔli:	lorry
mibu	nipple		

2.2.3 Formal statement of morpheme structure conditions. The foregoing characterisation of A's phonology at 2 years 60 days can be formalised along the following lines. The inventory of distinctive systematic phonemes, restricting ourselves to the consonants, can be expressed in the following matrix (table 2):[2]

TABLE 2. *Matrix of A's consonant phonemes at stage 1*

	b	d	g	m	n	ŋ	w	l
consonantal	+	+	+	+	+	+	+	+
syllabic	−	−	−	−	−	−	−	−
coronal	−	+	−	−	+	−	−	+
anterior	+	+	−	+	+	−	+	+
nasal	−	−	−	+	+	+	−	−
continuant	−	−	−	−	−	−	+	+

[1] Although CVCV items of the requisite shape did not occur at this stage, the examples given seem close enough to warrant their inclusion here.

[2] See Appendix B for a matrix characterisation of the adult consonant system.

Notes

(1) Following the suggestion in Chomsky and Halle, 1968 (p. 354), I use the major class features [consonantal] and [syllabic]; the feature [vocalic] is not used.[1] All consonants are $\begin{bmatrix} + \text{consonantal} \\ - \text{syllabic} \end{bmatrix}$; vowels are $\begin{bmatrix} - \text{consonantal} \\ + \text{syllabic} \end{bmatrix}$.

(2) Given the configuration $\begin{bmatrix} - \text{syllabic} \\ + \text{consonantal} \end{bmatrix}$, or even simply [−syllabic], it would of course be possible to characterise eight segments in terms of only three distinctive features. Four are used here to preserve congruity of specification with the adult system and a direct phonetic correlation of features at the phonemic and phonetic levels.

(3) |w| is characterised as [+consonantal] for three reasons:

(a) There is no evidence that A has more than a consonant/vowel distinction; and restricting his phoneme inventory to two classes simplifies the rules.

(b) |w| is in free variation and/or complementary distribution (see p. 37 above) with [v] and [β]. The choice of 'w' rather than 'v' as the relevant symbol was partly arbitrary, partly determined by the former's greater frequency of occurrence and the greater number of adult words with /w/ to which |w| corresponded. At a later stage (see p. 107 below) it will be seen further that [w] is in complementary distribution with [f], which is clearly [+consonantal].

(c) The realisation rules also require that |w| be [+consonantal] (see p. 59 below).

(4) |w| is characterised as [+anterior] (cf. Chomsky and Halle, 1968, p. 307) partly because it is here being used as a true consonant; partly because even when it is clearly a glide there is evidence from the realisation rules that /w/ must be characterised as [+anterior] (see R8, p. 26 above, and the treatment of *whistle* by, perhaps, R17, p. 19 above).

Although the vowel system is not the main focus of attention here (see 1.3.2 above), I provide in table 3 a characterisation of A's distinctive vowels at stage 1.

For comments on this system, see above, p. 39; and for the general problem of characterising vowel systems with more than three tongue heights in terms of binary features, see Smith, 1970–1.

[1] For some discussion of this usage, see 5.2.1.

TABLE 3. *Matrix of A's vowel phonemes at stage 1*

	i:	i	e:	ɛ	æ:	a:	ə:	ʌ	ɔ	o:	u	u:
consonantal	−	−	−	−	−	−	−	−	−	−	−	−
syllabic	+	+	+	+	+	+	+	+	+	+	+	+
high	+	+	−	−	−	−	−	−	−	−	+	+
back	−	−	−	−	−	+	+	+	+	+	+	+
low	−	−	−	+	+	+	+	+	+	−	−	−
tense	+	−	+	−	+	+	+	−	−	+	−	+
round	−	−	−	−	−	−	+	−	+	+	+	+

The morpheme structure conditions given informally in 2.2.2 above are formalised here, preserving the same numbering as before; though it should be noted that these conditions are not themselves ordered. Conditions MS1 and MS2 are canonical or 'positive' conditions (see Stanley, 1967); MS3–MS7 are sequential; and conditions MS8–MS10, which have no equivalent above, are segmental; i.e. they merely specify redundancies in the matrix.

All morphemes must be of the form characterised by MS1 or MS2:

MS1   # ([−syllabic]) [+syllabic] ([+syllabic]) ([−syllabic] [+syllabic])* ([−syllabic]) #

or, equivalently,   # (C) V (V) (CV)* (C) #

where C = $\begin{bmatrix} - \text{syllabic} \\ + \text{consonantal} \end{bmatrix}$ and V = $\begin{bmatrix} + \text{syllabic} \\ - \text{consonantal} \end{bmatrix}$.

Note that these abbreviations differ from those in general use: specifically, C does not represent a disjunction. The star notation[1] − (CV)* − is used instead of the multiple parentheses of p. 40 above, as the former captures the notion 'indefinitely long sequence of alternating consonants and vowels' without having to specify the length of the longest word. In other words when A learns his first quadrisyllabic word the parentheses of p. 40 would have to be extended, whereas the star notation claims there is no change (beyond the addition of one item to the lexicon). The latter seems intuitively correct.

$$\text{MS2} \quad \# \left(\begin{bmatrix} + \text{consonantal} \\ \alpha \text{coronal} \\ \beta \text{continuant} \end{bmatrix} \right) V \begin{bmatrix} + \text{consonantal} \\ \gamma \text{coronal} \\ \delta \text{continuant} \end{bmatrix} V \ldots \#$$

where either: $\alpha = \beta = \gamma = \delta$

or: $(\alpha \neq \beta)$ *and* $(\gamma \neq \delta)$

[1] See Chomsky and Halle, 1968, p. 344.

This condition says that either all the Greek variables must agree, or that the specification for both the initial and medial consonants must be different for these features. This is clearly a highly inelegant formulation, but if we abide by Stanley's well-motivated requirement that 'in the theory of MS conditions we *require* that positive conditions be used in stating restrictions on syllable structure' (1967, p. 432); if, in other words, we do not have recourse to the use of directionality in the statement of the conditioning of this harmony, then there is no immediately obvious alternative. Even if we reverted to the former characterisation of

'l' as $\begin{bmatrix} +\text{vocalic} \\ +\text{consonantal} \end{bmatrix}$, there is still the problem that a natural class

$\begin{bmatrix} \alpha\text{vocalic} \\ \alpha\text{consonantal} \end{bmatrix}$ would incorrectly predict that glides should behave the

same way. In fact the problem will arise whenever we have a constraint on a single element (here 'l'), where this element is specified by two or more features, so we cannot solve the problem by keeping $|w|$ as $[-\text{consonantal}]$, as we should still need to specify the segment as $[+\text{sonorant}]$ or $[-\text{nasal}]$ as well.

There are two ways round the impasse. One is to treat this kind of consonant harmony as Lightner (1965) suggests, by means of a lexical feature (his 'abstract morpheme marker') [LIQUID] for instance, and then have a rule:

$$[+\text{consonantal}] \rightarrow \begin{bmatrix} +\text{coronal} \\ +\text{continuant} \end{bmatrix} / [\overline{+\text{LIQUID}}]$$

But, in addition to the unfortunate fact that Lightner's convention would associate [LIQUID] with vowels as well as consonants, we still need a further disjunctive sub-part to the rule:

$$[+\text{consonantal}] \rightarrow \begin{Bmatrix} [-\text{coronal}] \\ [-\text{continuant}] \end{Bmatrix} / [\overline{-\text{LIQUID}}]$$

which seems quite wrong.[1] The other, preferred, alternative is to lift the restriction that MS conditions must be stated in terms of those features which are systematically utilised in lexical representations, and use *phonetic* features.[2] Thus in the present case, we could use the phonetic

[1] This would be equivalent to the older: $[+\text{segment}] \rightarrow \begin{Bmatrix} [-\text{vocalic}] \\ [-\text{consonantal}] \end{Bmatrix}$ i.e. specifying the unnatural class of consonants, glides and vowels; and just as suspect as the disjunction usually abbreviated as 'C'.

[2] As far as I know, this constraint has not been made explicitly in the literature. However, it seems well-motivated on general grounds, and appears to correspond to accepted practice.

feature [lateral], which is totally redundant at the systematic phonemic level, but must be specified somewhere to provide the correct phonetic output,[1] and then reformulate MS2 as:

$$\text{MS2}' \quad \# \left(\begin{bmatrix} +\text{consonantal} \\ \alpha\text{lateral} \end{bmatrix} \right) V \begin{bmatrix} +\text{consonantal} \\ \alpha\text{lateral} \end{bmatrix} V \dots \#$$

$$\text{MS3} \quad C \rightarrow [-\text{continuant}] / \rule{1cm}{0.4pt} \#$$

$$\text{MS4} \quad C \rightarrow [-\text{coronal}] / \rule{1cm}{0.4pt} V \begin{bmatrix} -\text{coronal} \\ -\text{anterior} \end{bmatrix}$$

$$\text{MS4a} \quad C \rightarrow [-\text{coronal}] / \begin{bmatrix} -\text{coronal} \\ -\text{anterior} \end{bmatrix} V [\overline{-\text{nasal}}]$$

(See the discussion of MS4 on pp. 41–2 above)

$$\text{MS5} \quad C \rightarrow [-\text{coronal}] / [\overline{+\text{nasal}}] V [-\text{coronal}]$$

$$\text{MS6} \quad C \rightarrow [+\text{anterior}] / [\overline{+\text{nasal}}] V [+\text{anterior}]$$

Note that these last two conditions, both of which clearly describe different manifestations of consonant harmony involving nasal consonants, and which are superficially very similar, are not collapsible beyond the trivial generalisation captured by:

$$\begin{bmatrix} +\text{consonantal} \\ +\text{nasal} \end{bmatrix} \rightarrow \begin{Bmatrix} [-\text{coronal}] / \rule{0.6cm}{0.4pt} [-\text{coronal}] \\ [+\text{anterior}] / \rule{0.6cm}{0.4pt} [+\text{anterior}] \end{Bmatrix}$$

$$\text{MS7} \quad [+\text{nasal}] \rightarrow \begin{bmatrix} +\text{coronal} \\ +\text{anterior} \end{bmatrix} / X \begin{bmatrix} +\text{syllabic} \\ -\text{stress} \end{bmatrix} \rule{1cm}{0.4pt}$$

Where $X \neq |\eta|$.

If we wished to avoid the verbal condition X could be characterised by the triple disjunction:

$$\begin{Bmatrix} [-\text{nasal}] \\ [+\text{coronal}] \\ [+\text{anterior}] \end{Bmatrix}$$

[1] If A is really operating the adult system (see chapter 4, *passim*), this objection would disappear; but in this section I am assuming that the child is operating an independent system.

It is worth noting that while the presence of the phonetic feature [lateral] allows us to sidestep the problem of formalising the sentence 'within a word all consonants must be $|l|$ or none must'; if the consonant harmony had operated on a segment which did not have such a simple, unitary phonetic specification we should still have faced the same problem. Presumably it is no more likely that a grammar should contain MS2 than that it should contain the same condition with 'r' substituted for 'l'. In this case, short of making up some *ad hoc* phonetic (or diacritic) feature characterising 'r', there is no satisfactory way of stating the restriction.

It should be noted that all of MS 2, 4, 5, 6, 7 impose harmonic constraints of some kind or other on A's language. For some discussion of consonant harmony in general, see 4.3.1.

MS8 $[+\text{coronal}] \rightarrow [+\text{anterior}]$

MS9 $[+\text{nasal}] \rightarrow [-\text{continuant}]$

MS10 $[+\text{continuant}] \rightarrow [+\text{anterior}]$

These last three segmental conditions exclude the eight non-occurring but logically possible combinations of the four features [coronal, anterior, nasal, continuant] used to specify A's systematic phonemic segments. MS9 should perhaps be excluded as it obtains by definition (see Chomsky and Halle, 1968, p. 317) and is therefore universal; but the other two, MS8 and MS10, represent specific constraints on A's system. Accordingly, we shall see that MS8 and MS10 change through time, whilst MS9 does not.[1]

2.2.4 Phonetic rules of A's system.

Finally, we need to specify the phonetic output of A's phonology by means of a set of phonetic rules, which operate on the phonemic representations generated by the MS conditions or, equivalently, by the realisation rules. It is not intended to give a 'conventional' (but as yet unexemplified!) set of *n*-ary specifications of the features used; rather, a finer phonetic specification in terms of other features will be added to the segments defined phonologically.[2] Moreover, even these rules are intended to be illustrative rather than exhaustive.

$$\text{Ph1}\quad \begin{Bmatrix} [+\text{continuant}] \\ [+\text{nasal}] \end{Bmatrix} \rightarrow [+\text{voiced}]$$

That is, sonorants are always voiced in all positions.

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[1] Except, that is, that features may be added to the right-hand side of MS9. See p. 113 below, where MS9′ is:

$$[+\text{nasal}] \rightarrow \begin{bmatrix} -\text{continuant} \\ +\text{voice} \end{bmatrix}.$$

[2] The real problem at issue, as in the difficulty with formulating MS2 above, is the relationship between the set of phonological features and the set of phonetic features; and within this problem, the further one of which set of features the MS conditions should range over. At first sight it might seem obvious that all features relevant, phonologically or phonetically, should be included in the 'segment structure' rules of the language being described; but this would have the unfortunate result – to take a very simple example – of rules having the exactly opposite effect of each other. Thus phonologically all segments in A's system are [+voiced], but some of them are phonetically [−voiced], i.e. we have one condition [+segment] → [+voiced], and a later rule [+segment$_i$] → [−voiced].... This is avoided if [voiced] is not specified at all until we reach the phonetic rules.

$$\text{Ph2}\quad \begin{bmatrix} -\text{continuant} \\ -\text{nasal} \end{bmatrix} \rightarrow \begin{Bmatrix} \begin{bmatrix} -\text{voiced} \\ +\text{HSP}^1 \end{bmatrix} /\!\!-\!\!-\!\!\# \\ \begin{bmatrix} -\text{voiced} \\ -\text{HSP} \end{bmatrix} /\#\!\!-\!\!- \\ \begin{bmatrix} +\text{voiced} \\ -\text{HSP} \end{bmatrix} \end{Bmatrix}$$

This accounts for the plosive allophones discussed on p. 37.

$$\text{Ph3}\quad \begin{bmatrix} +\text{continuant} \\ +\text{coronal} \end{bmatrix} \rightarrow [+\text{lateral}]$$

$$\text{Ph4}\quad \begin{bmatrix} +\text{continuant} \\ -\text{coronal} \end{bmatrix} \rightarrow \begin{Bmatrix} [-\text{consonantal}] \\ \begin{bmatrix} +\text{delayed release} \\ -\text{distributed} \\ -\text{sonorant} \end{bmatrix} \end{Bmatrix}$$

This accounts for the allophones of |w| discussed on p. 37.

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[1] Heightened sub-glottal pressure.