ASSESSING THE FUNCTIONAL ADEQUACY OF CHILDREN'S
PHONOLOGICAL SYSTEMS

Eeva Leinonen-Davies

Submitted in partial fulfilment of the
requirements for the degree of PhD

Leicester Polytechnic

March 1987

**PAGE 49 MISSING IN
ORIGINAL**

Tämä Väitöskirja on Omistettu Äidilleni Irja Leinoselle
ja
Veljilleni Heikille ja Markulle.

Acknowledgements

Many people have contributed to the development of the ideas in this thesis. My sincere thanks go to the staff at the School of Speech Pathology. John Connolly made a valuable contribution in the initial stages of the work. Dave Hiles and Dave Rowley gave advice and much needed support throughout the research in particular in the analysis of the data. The staff at the Leicester Polytechnic Computer Centre made an important contribution by pointing me in the right direction for the computational analysis and by providing a rescue service in moments of despair. There is also Pippa, my colleague and a dear friend, who shared my problems and achievements. But my warmest thoughts and thanks go to my supervisor, Pam Grunwell, who has provided me with unfailing support and encouragement, and invaluable comments and suggestions.

ABSTRACT

This study has developed the idea of assessing the functional adequacy of children's phonological systems which are restricted in terms of their contrastive potential. A phonological system is considered functionally adequate if it differentiates between the lexical items in a lexical system which is its function to support. Functional inadequacy resulting from the loss/absence of contrasts in a phonological system is reflected in the presence of homophony in a lexical system. The concepts and measures of Functional Loss (FLOSS) and Index of Multiple Homophony (IMH) have been developed to gauge the potential functional inadequacies of restricted phonological systems.

The absence of contrasts from children's phonological systems can be described in terms of phonological processes. Phonological processes have been observed to operate one at a time on a word or in combinations. It has been shown in this study that combinations of two processes can enter into relationships which result in predictable potential homophony in a lexical system and the ordering of these processes in combinations can be critical for the occurrence of homophony.

FLOSS-values and IMH have been calculated for a selection of phonological processes commonly found to operate in the speech of young normal children and children with disordered phonologies, on the basis of a sample of 'common' vocabulary of normal children. These values have provided a means of testing several hypotheses about the process relationships and functional adequacy put forward in the theoretical model. It has also been argued that the FLOSS-values and the IMH obtained can provide guidelines in the prioritization of treatment goals in the clinical management of phonological disability in children. Suggestions for such guidelines have been put forward on the basis of the results.

While this study is essentially a clinically-oriented one, the model developed is considered valid for the study of the functional adequacy of any phonological system which is restricted in terms of its contrastive potential.

Table of Contents

Tables and Figures

Appendices

Chapter 1: Introduction	1
Chapter 2: Background to the Study	5
2.1: On Functional Load Assessment	5
2.2: On Child Phonology	19
Chapter 3: Assessing the Functional Adequacy of Children's Phonological Systems	33
Chapter 4: Ordering of Phonological Processes	54
4.1: General Issues in the Ordering of Phonological Rules	54
4.2: Ordering of Phonological Rules or Processes in Child Phonology	63
4.3: Ordering of Phonological Processes in the Assessment of the Functional Adequacy of Children's Phonological Systems	70
4.3.1: Combinations of Phonological Processes Operating in the Same Place in Syllable Structure	71
4.3.1.1 Feeding and Bleeding Relationships	71
4.3.1.2 Feeding Relationships in the Present Study	74
4.3.1.2.1 Complete Feeding	74
4.3.1.2.2 Incomplete Feeding	77
4.3.1.2.3 Summary of the Different Types of Feeding Relationships	94
4.3.1.3: Conspiring Relationships	102
4.3.1.4: The Process Relationships and the Phonological Contrasts Missing from the Phonological System	107
4.3.2: Combinations of Phonological Processes Operating in a Different Place in a Syllable Structure	108
Chapter 5: Calculation of FLOSS-values and Indices of Multiple	110

Homophony for Phonological Processes	111
5.1: The Data Sample	120
5.2: The Method	120
5.2.1: The Phonological Processes Investigated in the Study	132
5.2.2: Use of Computer in the Study	140
5.3: Study 1: Single Phonological Processes	142
5.3.1: Results	148
5.4: Study 2: Combinations of Two Phonological Processes	153
5.4.1: Results	
Chapter 6: Discussion	191
6.1: Assessing the Clinical Relevance of the Theoretical Framework	209
6.2: Evaluation of Study 1 and Study 2 in Relation to the Theoretical Framework	
Chapter 7: Conclusions	221
References	226
Appendices 1 - 14	239

Tables and Figures

Table 2.1: Seven Principles Characterizing the Traditional
Functional Load Measures, following Meyerstein (1970)

Table 2.2: Age Limits of Customary Consonant Production (from
Sander 1972:63)

Table 3.1: Functional Adequacy vs. Communicative Adequacy

Table 4.1: Types of Ordering Relationships and their Opposite
Orders

Table 4.2: Summary of the Main Characteristics of the Feeding,
Counter Feeding Relationships Recognized in the
Present Study

Table 4.3: Summary of the Different Potential Effects of the
Feeding Relationships on FLOSS

Table 4.4: Summary of the Different Potential Effects of the
Feeding Relationships on Multiple Homophony

Table 4.5: Summary of the Main Characteristics of the Conspiring
Relationships Recognized in the Present Study

Table 5.1: The Mean Percentages of Word Usage by Eight Language
Disordered Children Studied by Leonard (1977) and
Eighteen Normal Children Studied by Nelson (1973)

Table 5.2: Vocabulary Growth in Children

Table 5.3: Comparison of Burrough (1957) and Wepman & Haas (1975)

Table 5.4: Overview of Phonological Processes

Table 5.5: The Status of the Eight Processes

- Table 5.6: The Phonological Processes Requiring Explicit Specification of Relevant Consonant Clusters in the Replace Command, when Operating in the SIWI Place in Structure
- Table 5.7: Words in the Data Sample Containing Consonant Clusters in the SFWW and/or the SIWW Places in Structure
- Table 5.8: Results for Study 1 (Appendix 4)
- Table 5.9: Rank Ordering of FLOSS-values for all Single Phonological Processes Studied in the SIWI Position (Appendix 5)
- Table 5.10: Rank Ordering of FLOSS-values for all Single Phonological Processes Studied in the SFWF Position (Appendix 6)
- Table 5.11: Rank Ordering of FLOSS-values for all Context-Independent Processes Operating in all Positions Simultaneously: Study 1
- Table 5.12: Mean FLOSS-values for Processes Operating in the SIWI or the SFWF positions: Study 1
- Table 5.13: Mean FLOSS-values for Process Categories: SIWI Position
- Table 5.14: Mean FLOSS-values for Process Categories: SFWF Position
- Table 5.15: Mean FLOSS-values for Context-Independent Processes Operating in the SFWW and the SIWW Places in Structure
- Table 5.16: FLOSS-values and IMH for Processes Entering a Complete Feeding Relationship in the SIWW Place in

Structure

Table 5.17: Rank Ordering of FLOSS-values for All Combinations of Processes Operating in the SIWI Place in Structure: Study 2 (Appendix 9)

Table 5.18: Rank Ordering of FLOSS-values for All Combinations of Processes Operating in the SFWF Place in Structure: Study 2 (Appendix 10)

Table 5.19: Rank Ordering of IMH for All Combinations of Processes Operating in the SIWI Place in Structure (exclusive of IMH of 2:1) (Appendix 11)

Table 5.20: Rank Ordering of IMH for All Combinations of Processes Operating in the SFWF Place in Structure (exclusive of IMH of 2:1) (Appendix 12)

Table 5.21: Rank Ordering of FLOSS-values for Processes Operating in the SIWI and SFWF Places Simultaneously: Study 2 (Appendix 13)

Table 5.22: Rank Ordering of IMH for Processes Operating in the SIWI and SFWF Places Simultaneously: Study 2 (exclusive of IMH of 2:1) (Appendix 14)

Table 5.23: Mean FLOSS-values for all Process Combinations Operating in the SIWI or the SFWF Positions

Table 5.24: Mean IMH (inclusive of IMH of 2:1) for all Process Combinations Operating in the SIWI or the SFWF Positions

Table 5.25: Mean IMH for All Process Combinations Producing Multiple Homophony (exclusive of IMH of 2:1) in the SIWI and the SFWF Positions

Table 5.26: Incidence of Multiple Homophony for ALL Process Combinations Operating in the SIWI or the SFWF

Positions

- Table 5.27: Mean FLOSS-values for Combinations of Processes Operating in the SIWI and the SFWF Positions Simultaneously as a Function of the Production of HIGH/LOW Independent FLOSS-values (i.e. in Study 1)
- Table 5.28: Mean FLOSS-values Differentiated for Combinations of two Processes which Consist of a HIGH Independent FLOSS-value in the SFWF Position on the Basis of a Deletion or a Substitution Process Operating in the SFWF Position
- Table 5.29: The Proportion of Non-Additive FLOSS-values for Combinations of Processes Operating in a Different Place in a Syllable Structure Simultaneously
- Table 5.30: The Proportion of Non-Additive FLOSS-values as a Function of the Production of HIGH or LOW Independent FLOSS-values
- Table 5.31: Mean FLOSS-values for Process Relationships in the SIWI and the SFWF Positions
- Table 5.32: Mean IMH (inclusive of IMH of 2:1) for Process Relationships in the SIWI and the SFWF Positions
- Table 5.33: Proportion of Multiple Homophony for Process Relationships in the SIWI and the SFWF Positions
- Table 5.34: Mean IMH (exclusive of IMH of 2:1) for Process Relationships
- Table 5.35: Mean FLOSS-values for Incomplete Feeding Relationships Consisting of a Conspiring Relationship:SIWI Position
- Table 5.36: Mean FLOSS-values for IF/Unaltered PS, Counter Feeding to IF/Unaltered PS, Type1IF and Counter

Feeding to Type1IF: SIWI Position

Table 5.37: Mean IMH for Incomplete Feeding Relationships
Consisting of a Conspiring Relationship: SIWI
Position

Table 5.38: Mean IMH for IF/Unaltered PS, Counter Feeding to
IF/Unaltered PS, Type1IF and Counter Feeding to
Type1IF: SIWI Position

Table 5.39: Mean FLOSS-values for Process Relationships
Operative in the SIWI Position as a Function of the
Alteration of Process Specifications

Table 5.40: Mean FLOSS-values for Type1IF, Type2IF, Type3IF,
Type4IF and Type3+4IF Relationships in the SIWI
Position

Table 5.41: Mean IMH for Type1IF, Type2IF, Type3IF, Type4IF
and Type3+4IF in the SIWI Position

Table 5.42: The Proportion of Non-Additive and Additive FLOSS-
values for Process Relationships: SIWI and SFWF
Positions

Table 5.43: The proportion of Non-Additive FLOSS-values which
are higher or lower than the Additive FLOSS-values:
SIWI and SFWF Positions

Table 5.44: Correlation Coefficients

Table 5.45: The Proportion of New Homophony Produced for Complete
Feeding Relationships: SIWI and SFWF Positions

Table 5.46: Correlation Coefficients

Table 6.1: Levels of Phonological Performance (from Hodson
1982:104)

Table 6.2: Incomplete Feeding Relationships with Altered
Process Specifications and their Relationships
to Conditions A and B

Table 6.3: Tendencies in Mean FLOSS-values Observed in Study 2

Table 6.4: Tendencies in Mean IMH Observed in Study 2

Table 6.5: Tendencies in the Proportions of Multiple Homophony
Produced

Figure 6.1: The Assessment of the Functional Adequacy of
Children's Phonological Systems

Figure 6.2: The Assessment of the Functional Adequacy of
Children's Phonological Systems on the basis of
a Contrastive Assessment

Figure 6.3: The Assessment of the Functional Adequacy of
Children's Phonological Systems Incorporating
the Findings of Study 1 and Study 2

Appendices

Appendix 1: The Data Sample

Appendix 2: Words Excluded from the Data Sample

Appendix 3: Specification of the Phonological Processes Included
in the Study

Appendix 4: Results: Study 1 (Table 5.8)

Appendix 5: Table 5.9

Appendix 6: Table 5.10

Appendix 7: Table 5.11

Appendix 8: Results: Study 2

Appendix 9: Table 5.17

Appendix 10: Table 5.18

Appendix 11: Table 5.19

Appendix 12: Table 5.20

Appendix 13: Table 5.21

Appendix 14: Table 5.22

Chapter 1: Introduction

The phonological systems of both young linguistically normal and linguistically disordered children differ from the adult system in terms of their relative inability to function contrastively (e.g. Smith, 1973; Ingram, 1976; Grunwell, 1981). The absence of adult contrastive phones in children's phonological systems results in homophony in their lexical systems, which in turn has a potential effect on the communicative adequacy of the phonological systems (e.g. Connolly, 1980; Grunwell, 1985).

This study develops a model for assessing the relative effects of missing contrasts from children's phonological systems on the adequacy of that system to signal lexical differences in a lexical system. Since the function of the phonological system of a language is lexical differentiation, a phonological system which differentiates between the lexical items in that language is referred to as a functionally adequate phonological system. A functionally inadequate phonological system results in homophony in the lexical system ensuing from the absence of contrasts from the phonological system.

The concept and measure of functional loss (FLOSS) is developed in this study on the basis of the concept of functional load (e.g. Hockett, 1966) to gauge the functional inadequacies of phonological systems which are restricted in terms of their contrastive potential. While FLOSS is essentially a system-based measure, it is argued that it may give some indication of the potential communicative consequences of restricted phonological systems. As a step toward a more 'communicatively oriented' assessment of children's restricted phonological systems, a further measure termed the Index of Multiple Homophony (IMH) is proposed.

The main motivation for the present study is to develop a model which has potential relevance for the clinical management of phonological disorders in children. It is argued that FLOSS-values and IMH are of interest in the planning of remedial goals in phonological therapy. Phonological contrasts missing from children's phonological systems need to be introduced into such systems in a principled manner. The present study facilitates the prioritization of treatment goals so that the functional adequacy of a restricted

phonological system can be maximally improved.

The absence of contrasts in children's phonological systems is frequently described in terms of phonological processes (Stampe, 1979). This framework of analysis has been employed in several clinical phonological assessment procedures (e.g. Hodson, 1980; Shriberg and Kwiatkowski, 1980; Ingram, 1981; Grunwell, 1985). In order to investigate the suitability of the phonological process analysis framework for the assessment of functional adequacy and in order to promote wider applicability of the present study, the model developed and the calculation of FLOSS-values and IMH are based on the phonological processes commonly found to operate in the speech of phonologically normal and disordered children. Phonological processes operate either one at a time on a word (e.g. /prt/→[bɪt]; Prevocalic Voicing) or in combinations (e.g. /trɪp/→[dɪp]; Cluster Reduction and Prevocalic Voicing). It is established in this study that combinations of phonological processes appear to enter into relationships which result in predictable potential homophony in a lexical system and the ordering of these processes in combinations is shown to be critical for the occurrence of homophony.

While the emphasis in this study is on the assessment of functional adequacy in the clinical context, it is also recognized that the concepts and measures developed are in principle applicable to the study of any phonological systems with restricted contrastive potentials.

Chapter 2 provides the background for the study. It surveys the issues which have contributed to the development of the ideas in this study. Section 2.1 overviews approaches to functional load assessment and Section 2.2 outlines issues on child phonology which are relevant to the assessment of functional adequacy.

In Chapter 3 the concepts and measures (i.e. FLOSS and IMH) for the assessment of functional adequacy are developed. A critical account of the measures of functional load is presented and the differences between the assessment of functional adequacy and communicative adequacy are highlighted. The potential clinical relevance of the assessment of children's phonological systems in functional terms is also considered.

In Chapter 4 the model for the assessment of functional

adequacy is developed further to take into account the operation of phonological processes in combinations and to consider potential ordering relationships into which phonological processes can enter. In Section 4.1 some general issues in the ordering of phonological processes (or rules) are outlined. Section 4.2 considers issues in the ordering of processes (or rules) in child phonology. These two sections provide a background for Section 4.3 which considers the role of ordering of processes in the assessment of the functional adequacy of children's phonological systems. This section forms a substantial part of the general model developed for the assessment of functional adequacy. Phonological process combinations are found to enter into predictable relationships with potential homophony. This finding in turn enables certain predictions to be made about potential functional consequences of phonological processes entering such combinations without the need to resort to ready calculated FLOSS-values or IMH.

In Chapter 5 FLOSS-values and IMH are calculated for phonological processes commonly found to operate in the speech of both phonologically normal and disordered children. Section 5.1 outlines the data sample selected to reflect 'common' vocabulary of children (aged 5;11 - 6;11) with normally developing phonologies. In Section 5.2 the method of analysis is considered. In Section 5.2.1 the phonological processes investigated in the study are outlined and Section 5.2.2 describes the use of a computer in the analysis. In Section 5.3 (STUDY 1) FLOSS-values and IMH are calculated for phonological processes operating one at a time on the lexical sample (i.e. single phonological processes). The results are tabulated and general tendencies are indicated. Section 5.4 (STUDY 2) presents FLOSS-values and IMH for combinations of two phonological processes which operate at the same time on the lexical sample and enter into certain types of process relationships. The results are tabulated and comparisons are made between different types of combinations in order to test the theoretical hypotheses about the types of process combinations and homophony put forward in Chapter 4, Section 4.3.

Chapter 6 provides a discussion and an evaluation of the theoretical model (Section 6.1) and the results obtained in Studies 1 and 2 (Section 6.2). Particular emphasis is placed on the

application of the study to the assessment of children's disordered phonological systems in order to arrive at suggestions for potential treatment goals in phonological therapy.

In Chapter 7 general conclusions are drawn. The potential applications of the concepts and measures developed in the study of restricted phonological systems other than those of children are also briefly considered.

CHAPTER 2 : Background to the Study

2.1 On Functional Load Assessment

The main purpose of this chapter is to overview various approaches to functional load assessment in order to provide a background for the assessment of the functional adequacy of the restricted phonological systems of children (Chapter 3). While some critical and evaluative remarks on the approaches discussed are made throughout this chapter, the approaches are further evaluated in Chapter 3 in relation to the assessment proposed in the present study.

The concept of functional load is well established in linguistics (e.g.. Martinet, 1955; Hockett, 1955, 1966; Greenberg, 1959; Rischel, 1961; Wang, 1967; King, 1967 a,b; Trubetzkoy, 1969; Meyerstein, 1970). The main issues are fairly clear. Functional load is used to:

"characterize in a general way the extent to which contrasts among members of a set of phonemes or a set of contrastive features contribute toward signalling of significant differences." (Greenberg, 1959:7).

The concept of functional load was originally formulated in connection with phonology, though its application to higher levels of language is possible in principle (e.g. Connolly, 1986). Initially, the notion of functional load was largely employed in a diachronic study of sound change (e.g. Martinet, 1955). This early hypothesis that functional load contributes toward sound change or is indicative of the direction of that change is now considered generally untenable. King (1967a), for instance, found no support for

- (i) The Weak Point Hypothesis which maintains that sound change starts from low functional load
- (ii) The Least Resistance Hypothesis which states that if there is a tendency for a phoneme to merge with one of two other phonemes, the merger will occur for the phoneme for which the functional load of the merged opposition is smaller.
- (iii) The Frequency Hypothesis which maintains that that member of the opposition with least frequent occurrence disappears.

Notwithstanding the demise of FLOAD in the diachronic field,

functional load has been recognized to have descriptive value. According to Hockett (1955:218) it is "a valuable addition to any description of a phonologic system". Functional load can also provide a useful dimension in contributing towards an understanding of such concepts as "linguistic information, language redundancy and such processes as speech recognition" (Wang, 1967:36). Consequently, it can also be a useful dimension in the study of speech intelligibility. If one was able to determine the relative importance of a phonemic contrast in a language system, one would have some indication of the potential impact of the loss of that contrast on intelligibility. This in turn could provide grounds for the application of this measure to speech therapy (cf. Beresford and Grady, 1968; Haas, 1968; Crystal, 1972, 1982; Connolly, 1984).

Two main types of approaches to the quantification of functional load are advanced in the literature: information theory based quantifications (e.g. Hockett, 1955, 1966; Greenberg, 1959; Wang, 1967) and non-information theory based approaches (e.g. King, 1967; Rischel, 1961). There is also a third approach, which can be described as being 'quasi-quantitative' in nature, in that the measure obtained is based on subjective judgements rather than objective mathematical calculations (i.e. Meyerstein, 1970). The 'precise' quantitative approaches will be examined first to provide the background for Meyerstein's extensions of these approaches.

Hockett (1955, 1966), Greenberg (1959) and Wang (1967) each propose a measure of functional load based on the information or the communication theory (Shannon and Weaver, 1949). However, they put forward slightly differing approaches in their application of the central concepts of the theory to the measure of functional load. The central concept of information theory is 'entropy'. The entropy of a text involves the average amount of information that is carried by phoneme tokens. It is computed on the probability of phoneme strings so that if the phoneme strings are all equiprobable, the entropy (or uncertainty) is maximum. As the differences between probabilities increase, the entropy decreases. Furthermore, if the entropy increases, the redundancy decreases, leading ultimately to zero. And conversely, if the entropy decreases, the redundancy increases.

The measure of functional load which is based on the number of

possible 'minimal' phonemic substitutions is related to entropy. If all phoneme strings are equiprobable, the more work the contrast between phonemes does to keep the word meanings apart. In other words, the higher the entropy, the higher the functional load value. Similarly, if the entropy of a phoneme string is zero, then there is only one possible phoneme to occupy a particular position, and thus no phonemic contrast between the phoneme present and other phonemes exists. In King's (1967b:8) terms,

"A functional load of a zero means either that two phonemes are in complementary distribution..., or that one of the two phonemes did not occur in the input text."

Greenberg's (1959) treatment of functional load is based on substitutability and entropy. While he measured tonal contrasts, nevertheless the procedure is seen to be valid for functional load assessment of "any set of phonemes or features for any language" (p.15). He begins with calculating the 'relative yield' which is "the total number of valid substitutions divided by the total number of phonemes which have significant tone for all the texts examined" (p.7). A valid substitution produced another grammatically possible, even if semantically improbable, sequence. The relative yield is not however adequate for measuring cross- and interlingual comparisons. If, let us say, two languages had the same relative yield and the frequency of the phonemes susceptible to tonal substitutions is greater in one language than another, then, according to Greenberg, the overall importance of the tone with the greater chance of occurrence is greater than the importance of the other tone. To account for this factor, the relative yield needs to be multiplied by the overall frequency of the phonemes susceptible to tonal features. This gives the measure of absolute yield.

The next step in Greenberg's treatment of functional load is to establish a relationship between substitutability and entropy. If combinatory possibilities are restricted, the choice of possible messages at that point is reduced, thus decreasing entropy. Such limitations also restrict the possibility of substitutions (see above). It is thus possible to use the same mathematical calculations for obtaining functional load values for contrasts as those used for the calculation of entropy. There is however a difference in the two in that the equivalent of the number of

choices at a particular point becomes the number of substitutions plus one for the actualized choice. The 'new' formula for the calculation of total phonemic yield, called 'first order compactness' reads

$$C = \sum_{s=0}^{n-1} p_s \log_2 (s+1)$$

in which 'p' stands for probability of occurrence and $\log_2(s+1)$ for the number of binary choices. The relationship between C and entropy (H) is $C \leq H$. In short, this relationship holds since "the constraints exercised by both preceding and following contexts involved in substitution are at least as great as those set up by preceding context alone as for entropy." (p.14). In addition to 'the first order compactness', successive higher orders of compactness are, at least theoretically, calculatable. Simultaneous substitution in two places of structure, for instance, yields second order compactness. Greenberg does not provide any practical means for arriving at such functional load values.

Greenberg's measure has been criticized by Wang (1967:47) for not being a very good approximation to entropy. According to Wang, there is a further methodological issue of some concern in Greenberg's approach. He points out that the reliance of Greenberg's approach on native speakers' ability to make judgements about valid substitutions is disadvantageous for a precise quantification since speakers may and do react differently to different degrees of grammaticalness. Greenberg's approach can however be credited for reducing sampling error, since the substitutions are made with reference to the entire linguistic knowledge of the speaker rather than a particular text.

Hockett's (1955,1966) approach is somewhat different from Greenberg's, not only because of the formidable number of calculations it entails, but also because of the starting point for the calculations. Instead of measuring the extent of 'work' done by contrasts to keep word meanings apart, he measures the extent of homophony caused by the obliteration of phonemic contrasts. To put it in information theory terms, Hockett's measure is directly related to the change in entropy of the phonemic system if

contrasted phonemes are neutralized. Entropy obviously increases as a function of neutralization.

Central to Hockett's view is that a phoneme system has a quantifiable job to do and a contrast between any two phonemes does its share. If the contribution of any two phonemes is withdrawn by conflating them, then, according to Hockett (1966:8), one of two things must happen:

- (1) The job done by the whole system is rendered smaller.
- (2) The total job remains the same, and the share no longer carried by the lost contrast is somehow divided up among the contrasts that remain.

The first point provides the main thesis for Hockett's approach, and is thus developed further.

According to the first point, it is possible to arrive at the functional load of the new system ($FL(N)$) by subtracting the functional load of the contrast obliterated ($FL(C)$) from the functional load of the system before the change ($FL(S)$), viz. $FL(N) = FL(S) - FL(C)$. It is thus apparent that if we find a measure of functional loads of whole systems, we have the functional loads of individual contrasts easily at hand, viz. $FL(C) = FL(S) - FL(N)$. The solution to the problem of finding such a measure is provided by entropy in that the functional load of a system is considered equal to the entropy of that system. That is to say, functional load reflects the state of uncertainty in the system, when contrasts are conflated. In addition to phonemic considerations, Hockett also examines the functional load concept in terms of allophones and components (features). The actual quantifications for allophones and components are essentially the same as the quantification for phonemic contrasts.

Whereas Hockett's quantifications (see Hockett, 1966) are mechanically cumbersome and time-consuming, especially since they involve calculating entropy twice, Wang's (1967) measure avoids these disadvantages. It represents a direct application of the notion of uncertainty to phonemes and their environments. The basic unit for the measure is 'conditional probability'. For instance, the conditional probability of f_j , given 'the first order left environment' f_i , is the ratio of the number of $f_i f_j$ tokens to the number of tokens of all phoneme pairs, which begin with f_i i.e.

$$p(f_i f_j) = \frac{n(f_i f_j)}{n(f_i x)}$$

On the basis of the conditional probabilities, a measure of $I(f_i f_j)$ is obtained, which signifies the amount of uncertainty that is contributed by phoneme f_j to the environment f_i as compared to the uncertainty contributed by the whole phoneme set, giving the following equation:

$$I(f_i f_j) = - \frac{P(f_i f_j)}{P(f_i a)} \log \frac{P(f_i f_j)}{P f_i a}$$

By extension, the amount of uncertainty that is contributed by the phonemes of the set 'a' is then simply a sum of the relevant I's:

$$H(f_{ia}) = \sum I(f_i f_j)$$

This equation is only satisfactory for calculating functional load values for contrasts in one specific environment. If one wanted to calculate all the other environments of the phonemes in question, one would need to use a 'weighting' function (cf. Greenberg, above). This is necessary, because not all environments occur equally often. thus, the following measure of functional load is proposed:

$$g(a) = \sum p(f_i) H(f_i a)$$

According to Wang, this formula does not get "unmanageably complicated when 'a' contains a large number of phonemes" (p.49).

There is not much to distinguish between the three information theory based formulae. As we shall see shortly, they are all very 'traditional' in their approach in that they consider only binary oppositions, base their calculations on frequency of occurrence only and consider only the formal function of phonemes. The approaches described can also be criticized as being 'sequential' rather than 'hierarchical' in nature (cf. Rischel, 1961, below).

King (1967a, 1967b) differs from all the other quantifications in that he provides not only theoretical discussion of the questions involved, but also empirical data on functional load from diachronic studies of several languages in the Germanic family. The formula proposed is phonemic in nature, "though it can be used to provide an estimate of the functional load of a distinctive feature" (1967a:7). It is a product of two factors: A measure of global text frequencies of the two phonemes in opposition and a measure of the degree to

which the two phonemes contrast in all possible environments. This produces the following formula,

$$L(x_i, x_j) = \left(\frac{N_i}{N}\right) \times \left(\frac{N_j}{N}\right) \times \sum_{k=1}^m \left(\frac{f_{ik}}{N_i}\right) \left(\frac{f_{jk}}{N_j}\right)$$

in which

- (i) N_i and N_j = total number of x_i or x_j phonemes
- (ii) N = total number of phonemes in a text
- (iii) $\sum_{k=1}^m$ = summation running through from 1st to last environment
- (iv) f_{ik} and f_{jk} = total number of x_i or x_j in environment k

Basically the formula measures the relative text frequencies of the two phonemes in a particular environment. Thus, if the text frequencies are high or low, the functional load values are high or low. But as we shall see shortly, this does not necessarily need to be so (cf. Meyerstein, 1970).

The final quantification study (Rischel, 1961), although also 'traditional' in nature of the actual formula proposed, differs from the other four in its recognition of the importance of levels of analysis higher than the phonemic level. Rischel examines this issue in terms of hierarchical versus sequential procedures. In short, in a sequential analysis phonemes are considered as unilinear sequences. In other words, no note is taken of the wider context in which they occur. As Rischel demonstrates, the load carried by a phonemic opposition is affected not only by the position of the phoneme in a word, but also by the position of the word in a phrase, the phrase in a sentence and so on. For instance, it does indeed make a considerable difference to load assessment to recognize that not all minimal pairs have an equal probability of occurrence in similar contexts. Rischel (1961:19) writes in this connection: "Even if both members of a minimal pair are frequent, this does not mean that the minimal contrast between them is necessarily used very much in speech communication.". Minimal pairs such as 'bad:mad' or 'bake:make' are obviously 'commutable', whereas such pairs as 'bean:mean' can hardly occur in identical contexts. Thus, in order to get an optimal approximation to the 'real degree of utilization' of a phonemic contrast, it cannot be treated as an out-of-context entity. But as Rischel appropriately points out, even in a hierarchical procedure one must choose a suitable highest unit of reference, rather than go further and further up the hierarchy, in

order to avoid formidable computations. One could also end up with a situation where everything is in complementary distribution with everything else (i.e. the whole text). In his proposed formula for functional load, the cut-off point is at the level of syllable.

The actual calculation of functional load values for phoneme contrasts in a particular place in structure is as follows. The probabilities of occurrence for all the phonemes occurring in a particular place in structure are calculated. Next, a relative measure of the functional load of each difference between two phonemes is obtained by multiplying the probabilities of the phonemes. And finally, each of the multiplications is divided by the sum of all multiplications calculated for the phonemes in the particular place in structure. Furthermore, in order to know the overall load of the phonemic difference within the consonant positions, it is necessary to determine the relative frequencies of the syllable types i.e. 'weight the results'. As was pointed out earlier, whereas Rischel recognizes the importance of the word, phrase, sentence and even higher levels of language in connection with functional load, he does not propose any practical means for achieving such calculations. One must seriously question, whether indeed it is practicable or possible to determine in any 'rigorous' fashion the probability of occurrence of one word over another in a given context and in communication.

All the approaches described so far are fairly 'traditional' in nature in that they adhere to certain 'principles' concerning the form and function of the items subjected to load assessment. In order to be able to extend and amend this approach, one needs to identify its main characteristics. Meyerstein (1970) puts forward seven principles, which describe the characteristics upon which he bases his extensions of the existing load work (see Table 2.1, overleaf).

Meyerstein takes issue with Hockett, who maintains that the qualitative aspects of functional load have been taken as far as possible (eg. Martinet, 1955) without considering the quantification of functional load. The main thesis of Meyerstein is to show that the extension of the scope of functional load is to be achieved "not by quantitative diversification within one area of functional

TABLE 2.1: Seven 'Principles' Characterizing the Traditional Functional Load (FL) Measures, following Meyerstein (1970)

Principle	Definition
1. Non-unitary Principle	FL of opposition of units (generally binary) is measured rather than FL of one unit.
2. The Principle of Non-zero counter-parts	Unit vs zero contrasts excluded from FL assessment.
3. The Principle of Sub-morphemic Level	The units in opposition are restricted to the phonemic level.
4. The Principle of Unique Function	Only the function of semantic differentiation considered.
5. The Principle of Frequency vs Load	Predominant view holds that frequency results in FL.
6. The Principle of Complimentary Distribution	Absence of a contrast entails absence of FL.
7. The Principle of Systemic Uniqueness	Only one, undifferentiated system considered

significance, but by diversifying the number of relevant areas" (p.62).

Whereas Meyerstein's approach is primarily qualitative in nature, he does however propose an alternative to the computation of functional load, which is called 'a differential statement'. Its sole concern is that "different form units (or oppositions viewed as units) differ in respective functional significance" (p.69). The differences are expressed in 'load points'. A given form may score a load point in addition to the score of its 'peers' (= "of replaceable or co-occurring forms of the same order) for such factors as denotative value, lexical differentiation or acquisitional effort. The feature which scores the additional load point is termed 'overload'. These concepts can be clarified with the following example from Meyerstein. If we compare Latin 'avunculus' and 'patruus' with French 'oncle' in point of vocabulary extent, Latin beats French 2:1 (two load points to 1 load point; note this does not imply mathematical doubling), but French beats Latin 2:1 in terms of semantic content. 'Oncle' has to perform the work load shared by the two Latin words. This example also conveniently shows how one area of functionality such as frequency may or may not coincide with that of another area, in this case denotative force.

Let us now return to the seven principles shown in Table 2.1 and examine Meyerstein's treatment of them. In reference to the first principle, Meyerstein's view is that the load concept is also applicable to unitary comparisons. It needs to be recognized, however, that the unitary view does not depart from the notion of opposition as such. It obviously is not possible to measure functional load of a unit per se, since the notion of 'importance' entails comparison. What the unitary view then means is that different aspects of a single phoneme can be measured in terms of their relative importance in the communicative system. Rischel's (1961:86) assignment of a high functional load value to the syllable initial /dʒ/ in 'Joe!' (vs. Go!) as compared to /dʒ/ in 'My name is Joe', serves to illustrate this point.

The second principle ('non-zero counterparts') is a consequence from the unitary principle. In traditional terms, it is obvious that the functional load of a single phoneme would have to be zero since "it has nothing with which to produce contrast" (Wang, 1967:43). But

as Meyerstein points out, 'unit vs. zero' correlation is essential if we wish to account for such minimal pairs as 'hill' vs. 'ill' and not only for such pairs as 'hill' vs. 'bill'. It should be noted however, as is pointed out by Kučera (1974:170), that this is more "a criticism of the prevalent practice than the theory of quantitative approaches, since the 'zero' element could rather easily be incorporated in FL calculations, given an extended definition of what constitutes the relevant environment for such quantifications".

In reference to the third principle, Meyerstein extends load assessment traditionally restricted to submorphemic levels, to supraphonemic levels. For example, rather than differentiating categories within the same functional set (e.g. verbs or nouns), some oppositions gain added importance by performing grammatical differentiation between diverse sets. According to Meyerstein, we may arrive at misleading functional loads without such considerations. For instance, if we consider only the relative frequency of the English phoneme pair /θ,ð/, we arrive at a low score, as compared to the correlation of /θ,ð/ in such word pairs as /maʊθ, maʊð/. In the latter case, the distinctive value of the two phonemes is maximal from the grammatical point of view.

As the fourth principle maintains, the traditional load assessments have considered only semantic function in relation to functional load. But as Meyerstein points out, some phonemes are also potential carriers of other distinctive functions such as grammatical (see above). One reason for functional load work not venturing beyond the purely formal functions lies in the preponderance of quantitative over qualitative approaches: formal semantic function is indeed much easier to define and calculate than the functions of 'real' communication.

According to the fifth principle, frequency is associated with a unit and functional load with binary frequency values. Since it is traditionally maintained that frequency results in functional load, any forms or functions for which frequencies cannot be calculated are then excluded from functional load assessment. Meyerstein queries whether the lack of computational potential is a good enough reason to exclude such factors as availability, learnability or usefulness from load assessment. To him there is no justification

for excluding these and other similar factors, which leads him to distinguish between frequential and non-frequential loads and variables. Indeed, his 'quasi-quantitative' load point method is 'imprecise' enough to allow some kind of quantification of non-frequential variables. While one must realize, that the impressionistic nature of the load point approach can be accepted as an operational hypothesis for the early stages of research using this approach, it has to be noted that nothing further has come of it since. It does indeed seem somewhat difficult to come up with any precise enough quantifications based on this approach to allow any practical use of it (cf. communicative vs. functional adequacy, Chapter 3). As Kučera (1974:173) points out in this connection, even if the non-frequential load values were quantifiable, we would be left with "a whole series of atomistic statements", which could not be summarized into a coherent overall statement about the functional load properties of a whole system.

The doubtful value of frequency as a unique factor in determining functional load is further supported by the principle of "complementary entailing zero load". Two forms in complementary distribution may be fairly frequent, yet result in functional load of zero. In accordance with his questioning of the unitary principle, Meyerstein also questions the principle concerning complementary distribution. If a functional load assessment considers forms which are aspects of one phoneme, then obviously the 'traditional' principle of complementary distribution has no relevance to the analysis.

The final principle (systemic uniqueness) refers to the traditional practice of relating formal functionality to one, undifferentiated system. In regard to this point, Meyerstein considers three different issues: the distinction between competence and performance within one system; the distinction between different sub-systems within one system; and the distinction between two different systems.

There is not much to distinguish between the formulae based on the information theory and the formulae based merely on frequency of occurrence. The main characteristics, as outlined in Table 2.1, remain the same: Functional load is measured in terms of probability of occurrence of phonemic oppositions in given environments.

Meyerstein's extensions of load assessment is a step toward gauging 'the real degree of utilization' of contrasts. Yet, it seems unreasonable to hope to implement such a 'communicative load assessment' in practical terms, with our still limited knowledge of the factors which have relevance for the importance of one phonemic contrast over another in 'real' communication.

The discussion thus far has overviewed approaches to the quantification and conceptualization of functional load. In a recent paper Connolly (1986) has examined in some detail how the concept of functional load could be applied to the study of speech pathology with special reference to planning programmes of remediation for patients with language disorders. The central thesis of the paper is that the concept of functional load facilitates the comparison of the cost of deficiencies in any pair of systems in functional terms and as such enables severity-rankings of systems. The actual quantification of functional load is based on Connolly's (1980) notion of the contrastive power of the system, which is calculated by the formula

$$C = \frac{N(N-1)}{2}$$

in which 'N' signifies the number of terms in parallel distribution in the system. To illustrate the calculation of functional load Connolly gives the following example from the level of grammatical analysis. The adult English modal system consists of 13 modal auxiliaries which contrast with one another. According to the above formula, the contrastive power of the system is $C = 78$. The modal system is capable of signalling 78 contrastive distinctions. This in turn is seen as the measure of functional load. It is then easy to calculate the functional load of a reduced modal system and by comparing the two functional loads, calculate " the number of functional distinctions which the patient is unable to signal " (p.13). A functional distinction is defined as " a difference between a pair of units at one level which signals non-identity between units at the next level " (p.3). While it is not made explicit how the respective functional load values are to be compared, it appears that this comparison involves taking the ratio

of the value for the incomplete system to that of the complete system.

Connolly's conceptualization of functional load is different from the previous approaches in one main regard. Functional load is considered a purely system-based concept in that no consideration is given to frequency of occurrence of linguistic items in texts and contexts. There is yet another aspect to the system-based nature of the analysis. The formula enables the calculation of functional loads of whole systems and not of linguistic contrasts within the system. Functional loads of individual contrasts could however be measured by calculating the load values of complete and reduced systems (the reduced system reflects the absence of the contrast one wants to study) separately and then subtracting the latter from the former (cf. Hockett, 1966; above). This is obviously somewhat cumbersome in that it necessitates the calculation of functional load twice in order to obtain the functional load of a single contrast.

Connolly's measure has essentially been developed for the study of the functional consequences of reduced linguistic systems. The purpose is to enable one to measure the functional 'loss' in a reduced linguistic system. We shall discuss in some detail in Chapter 3 whether the measure does indeed gauge the functional adequacy of such linguistic systems. We shall also examine whether the concepts developed by Connolly are readily applicable for the investigation of the functional consequences of reduced phonological systems. While all the illustrations in the respective paper are from the level of syntactic analysis, Connolly maintains that the measure is also applicable to the level of phonology.

In this section various approaches to the assessment of functional load have been overviewed. Some evaluative remarks have been made throughout the discussion. In the next chapter (Chapter 3) the concept of functional load and its applicability to the study of the functional adequacy of children's reduced phonological systems is fully evaluated.

2.2 On normal and disordered phonology in children

The purpose of this section is to discuss selectively certain aspect of normal and disordered child phonology. The emphasis will be on those aspects which have direct relevance for the assessment of functional adequacy. Particular attention is paid to the occurrence of phonological processes and the incidence of homophony in child speech.

It is commonly maintained that children with normally developing phonologies acquire most of the segmental and the suprasegmental elements of their language between the ages of 1;6 and 8;0 (e.g. Templin, 1957; Olmsted, 1971; Sander, 1972; Ferguson and Farwell, 1975; Moskowitz, 1975; Prather et al 1975; Ingram, 1976; Ferguson, 1978; Grunwell, 1980, 1986; Ingram et al, 1980; Klein, 1981; Stoel-Gammon and Dunn, 1985). Since the present study concerns segmental elements only, we shall not pursue the suprasegmental acquisition any further. Furthermore, we shall concentrate on the consonantal rather than vowel segments. Although it is recognized, that there is considerable variation in the order and age of acquisition of consonants (cf. Jacobson, 1968), there are general developmental patterns in terms of place and manner of articulation of consonants in normal phonological acquisition. Stops, nasals and glides are often acquired before fricatives affricates and liquids. Front consonants are also commonly acquired before back consonants. These tendencies are evident in Table 2.2 (overleaf), which summarizes the age of 'customary production' and mastery of consonantal phonemes as suggested by Sander (1972). He reviewed the data from the studies of Wellman (1931), Poole (1934) and Templin (1957) to arrive at these age norms. The age of customary production refers to the level when a 50% correct performance at all structural positions is acquired. The 'mastery' of the consonantal phonemes refers to the level when 90% of the population of children studied customarily produced the sound. Clusters of two or more consonants tend to be acquired rather late (e.g. Grunwell, 1980). As regards phonemes being mastered in one position before other positions, there seem to be individual variation in this regard. For example, Branigan (1974) studied a child who focused on the initial segments of a word whereas Kiparsky and Menn (1977) studied a child who produced all new sounds

Table 2.2: Age Limits of Customary Consonant Production
 (The solid bar starts at the median age of customary production and stops at an age level at which 90% of all children are customarily producing the sound.) (from Sander 1972:63)

first in the word final position.

Grunwell (1980) points out, that the establishment of age norms for the acquisition of adult phonemes may be considered a questionable, if not a meaningless exercise. There is a wide range of individual variation in the acquisition of phonemes. Moreover, a child's production of sounds is influenced by the interaction of phonetic and other factors. Grunwell further points out, that many of the studies on 'the age of phoneme acquisition' are in fact based on a 'theoretically false premise': " A child does not acquire separately each of the phonemes of his language; he only uses these speech sounds as the 'phonemes' of the language when he has developed the complete adult system of sound contrasts." The main goal of phonological acquisition is indeed the acquisition of contrasts to allow lexical differentiation, and consequently adequate communication.

In order to be able to investigate phonological contrastiveness in child speech, it is necessary to indicate how a misarticulated or an omitted target phoneme is in fact realized. The traditional studies addressing the issue of 'when are speech sounds learned' fail to give information in this regard. This is not however the case with studies which describe child realizations in relation to adult targets. These approaches have become the most popular analytical procedures in recent years in the description of both normal and disordered phonologies. The relationships between child realizations and adult targets have been expressed in terms of distinctive features (e.g. Crocker, 1969; Compton, 1970; Cairns and Williams, 1972; Oller, 1973), phonological rules (e.g. Oller, 1973; Smith, 1973) and phonological processes (e.g. Olmsted, 1971; Edwards and Bernhardt, 1973; Lorentz, 1974; Ingram, 1976, 1981; Shriberg and Kwiatkowski, 1980; Schwartz et al, 1980; Grunwell, 1981, 1985). In addition to the description of child realization and adult target relationships, there is another approach to the analysis of child speech, which also presents the contrastive phones in the child's phonological system. This is the analysis of the child's own independent phonological system (e.g. Grunwell, 1981; Stoel-Gammon and Dunn, 1985). This analysis involves searching through a sample of child speech for indicators of contrastiveness of the phones present in the child's phonetic inventory. At the

present time, the phonological process framework has become the most commonly used procedure in the description of normal and disordered child language. According to Stoel-Gammon and Dunn (1985:36) phonological processes "provide the simplest and most economical way of describing the differences in the structural and segmental aspects of the two forms (the child and adult forms)".

Phonological process analysis as a means of describing child speech originates from David Stampe's (1979) theory of Natural Phonology. While phonological processes are now used essentially as a sophisticated type of error analysis (Grunwell, 1982) to reveal patterns and regularities in child speech, it was originally developed to illuminate and explain the acquisition of phonology. The child is assumed to 'possess' an innate set of natural phonological processes, which operate on language, facilitating phonological development. Since the processes are assumed to be innate and universal, the acquisition process involves accommodation of these processes to the requirements of the ambient language. As the child progresses towards the particular adult system, phonological processes are suppressed, limited or modified in some other ways (e.g. ordering; see Section 4.2, below). Thus, fewer and fewer processes operate on the language input as the child's phonological acquisition progresses.

Phonological processes are considered 'natural', since they reflect the needs and capacities of the child. According to Stampe (1969)

"A phonological process merges a potential opposition into that member of the opposition which least tries the restrictions of the human speech capacity."

The child needs to communicate, but because of 'restrictions' in his production capabilities, the adult targets become simplified. Stops, for example, are said to be easier to produce than spirants, since they require a less controlled approximation of the articulators (Donegan and Stampe, 1979). Stopping of fricatives (e.g./[u/→[tu]) is indeed a well attested pattern in both normal and disordered child speech (e.g. Ingram, 1976). It needs to be recognized however, that judging relative ease or difficulty of production is not an easy or straightforward task, and thus, a fair amount of speculation is always present in such an interpretation.

Stampe refers to phonological processes as operating mainly at the level of language production. However, it is highly plausible, that language input may also be simplified due to perceptually based strategies or due to restrictions on a child's organizational capabilities (e.g. Ingram, 1976; Aitchison and Chiat, 1980). Unfortunately, it does not seem possible, with our still limited knowledge of the development of perception and of children's ability to store and retrieve language, to allocate specific processes to specific levels of language. Therefore, 'bold' attempts at such allocations, such as Ingram's (1976:65), should be considered primarily as hypothetical. To take an example, Ingram's proposal that Cluster Reduction (e.g. /plein/ → [pein]) can be interpreted as perceptual in nature in Ethel's speech is somewhat debatable. In addition to perceptual considerations, clusters may be reduced due to difficulty in articulating two adjacent consonants. Alternatively, the child's system of organizing linguistic information as a mental representation may only allow 'consonant-vowel' sequences of sounds. These different 'levels of operation' may also be interacting to produce a particular outcome. Furthermore, they may be employed in different ways and to different degrees during different developmental stages.

Stampe considers phonological processes psychologically real in the sense that they are assumed to shed light into the ways in which a child acquires language. While some other investigators also consider phonological processes psychologically real (e.g. Ingram, 1976; see Section 4.2, below), others attribute phonological processes primarily descriptive value (e.g. Grunwell, 1981; see Section 4.2, below). It appears that the data currently available are not sufficient to allow one to determine the psychological status of phonological processes (e.g. Derwing, 1977). At the present, phonological processes may be best regarded as providing the means of describing, rather than explaining, error patterns in child speech.

Although there is considerable variation in the incidence of phonological processes (e.g. Ingram, 1976; Shriberg and Kwiatkowski, 1980; Hodson, 1980), certain processes may be considered more

'common' in child phonologies. The following eleven processes are commonly attested in the literature on normal children: Weak Syllable Deletion, Reduplication, Cluster Reduction, Vocalization, Final Consonant Deletion, Stopping, Fronting, Gliding, Consonant Harmony, Prevocalic Voicing and Word Final Devoicing (See Chapter 5, Section 5.2.1 for a discussion of common phonological processes.).

The phonological processes found to operate in child speech can be viewed as simplifying the adult forms in two ways:

- (i) Processes modify the syllable structure of the target word (e.g. Weak Syllable Deletion: /bə, 'lun/ → ['lun]; CV, CVC → CVC).
 - (ii) Processes modify the contrastive function of the phonemic system (e.g. Stopping of /f/ to [p]: /fɪt/ → [pɪt]).
- (Grunwell, 1982, 1985)

These modifications may be achieved by substitution or omission of segments. Processes encountered in child speech do not necessarily fit neatly into one or the other of these 'categories'; some processes may have both of the above functions. For example, Cluster Reduction and Final Consonant Deletion (two of the 'common' phonological processes described in Grunwell; 1982) have both structural and systemic effects.

e.g. Cluster Reduction /spm/ → [pɪn]

CCVC → CVC

Final Consonant Deletion /sɪd/ → [sɪ]

CVC CV

Grunwell classifies these two processes as effecting structural simplifications. Furthermore, Grunwell (1982:172) categorizes Consonant Harmony (e.g. /dog/ → [gog]) as a structural simplification in that

- (i) "it results in a phonetically-simpler sequence of consonants"
- (ii) "the harmonized target consonants are usually found to occur in other contexts".

As such the terms 'structural' and 'phonetically simpler' appear to be interpreted differently for Consonant Harmony and the 'pure' structural simplifications of Weak Syllable Deletion and Reduplication (e.g. /ræ, bɪt/ → [wæ, wæ]). For these two phonological processes, 'phonetically simpler' forms are produced by virtue of structural simplifications. That is to say that the phonotactic

structures of words become simplified. In regard to Consonant Harmony, however, phonetically simpler forms result from systemic simplifications. That is to say that the phonetically simple form [gog], for example, results from the systemic neutralization of the contrast /d/ versus /g/ in the word initial position in the context of a following /g/. Because of the tendency of the harmonized consonants to function contrastively in contexts which do not induce harmony, Consonant Harmony may be best considered a systemic simplification, which however differs from the other systemic simplifications in that the neutralization of the contrast is contextually conditioned. This argument applies also to Vocalization (e.g. /bo,tl/→[bo,tʌ]), which is also classified as a structural simplification by Grunwell.

Phonological processes tend to operate in combinations on a child's phonological system. For instance, a child realization of [dit] for 'cheese' may be conceptualized as resulting from the operation of four processes.

e.g./tʃi:z/ tʃis WF Devoicing z-s
 tʃit Stopping s-t
 tit Stopping tʃ-t
 [dit] Prevocalic Voicing

N.B. the derivational steps in the example do not represent actual or potential developmental stages. Multiple processes operating on a word, may need to be ordered to produce the required outcome (see Section 4.2, below).

The speech of children with disordered phonologies is largely describable in terms of the same phonological processes, which are found to characterize the speech of children with normally developing language (e.g. Lorentz, 1974; Edwards and Bernhardt, 1973; Oller, 1973; Ingram, 1976; Schwartz et al, 1980; Grunwell, 1981; Weiner and Wacker, 1982; Dunn and Davis, 1983; Camarata and Gandour, 1984). Furthermore, Hodson and Paden (1981) demonstrated on the basis of their comparison of a group of normal 4-5 year olds and a group of unintelligible 3-8 year olds, that the phonological development of the disordered population may become 'arrested' at some stage. The disordered population demonstrated processes which are found in the speech of young normal children, whereas the normal population evidenced only errors on such single sounds as /θ, ʒ, l,

ɣ/ (also Weiner and Wacker, 1982). Moreover, like young normal children, disordered children typically have a reduced inventory of sounds and the syllable structure of their words tend to be simple. Grunwell (1981), for instance, reported the syllable shapes of CV and CVC as the most frequently occurring in the speech of her seven subjects.

In addition to the many similarities in the speech of normal and disordered children, certain differences exist. As regards phonological processes, the phonologically disordered speech is found to give evidence of some idiosyncratic processes (e.g. Edwards and Bernhardt, 1973; Ingram, 1976; Grunwell, 1981; Weiner, 1981; Dunn and Davis, 1983; Pollock, 1983; Camarata and Gandour, 1984; Leonard, 1985). The term 'idiosyncratic' refers to those processes which are reported to occur infrequently or not to occur at all in the normal child population. Thus, idiosyncratic processes may be potentially normal. Grunwell (1981:99) makes a distinction between idiosyncratic and unusual processes. The former refers to patterns, which "have not yet been reported as having occurred in normal development". The latter refers to "those processes whose occurrence has been reported only occasionally in (allegedly) normal development". Furthermore, the unusual processes reported in normally developing phonologies (e.g. Priestly, 1977) are usually of restricted application and short duration. Weiner (1981) describes a child with an idiosyncratic tendency to substitute /h/ for all initial voiceless fricatives and stops both in singletons and clusters. Weiner called this extreme tendency 'sound preference'. Grunwell (1981) identified a number of unusual and idiosyncratic processes in the speech of her seven subjects. These included the idiosyncratic lateral preference of Tanya, whereby all stop+approximant clusters were realized as stop plus an apical lateral (e.g. /prɜm/ → [plɜm]). The variety and frequency of occurrence of idiosyncratic or unusual processes in the phonologically disordered have not yet been systematically documented.

The patterns or processes in the speech of phonologically disordered children can be considered as indices of the nature of the disorder. Several 'indicators' of the presence or the severity of a phonologically based disorder are reported in the literature:

- (1) The occurrence of phonological processes is irregular and

inconsistent.

(2) Phonological processes persist beyond the expected ages of occurrence in normal children.

(3) Some of the earlier processes co-occur with speech patterns characteristic of later development. Grunwell (1981) refers to this as chronological mismatch.

(4) Some unusual or idiosyncratic processes are evidenced in the speech.

(5) The phonological system becomes 'static' from an early level of development, failing to progress toward mastery.

The speech of phonologically disordered children is also characterized by extreme variability (e.g. Edwards and Bernhardt, 1973; Lorentz, 1974; Grunwell, 1981; Weiner and Wacker, 1982). Stoel-Gammon and Dunn (1985:119-120) identify three types of variability:

(1) The production of the same target phonemes across different lexical items varies.

e.g. /s/ sun → [tʌn]
 soap → [sɒp]
 suit → [sut]
 sit → [dɪt]

(2) The production of a target phoneme within the same lexical item varies.

e.g. /s/ sun → [sʌn]
 [tʌn]
 [dʌn]

(3) The production of several target phonemes across several words varies.

e.g. sun → [sʌn]	shoe → [su]	chick → [sɪk]
[tʌn]	[tu]	[tɪk]
[dʌn]	[du]	[dɪk]
[sʌn]	[su]	[sɪk]

These types of variability are 'systemic' in nature in that several of the child's contrastive phones overlap in the pronunciation of words. Variability may also be developmental in nature, in that it indicates the potential for the establishment of new contrasts. Since such 'progressive variability' (Grunwell, 1981) is also present in normal child speech, the absence of any variability may be clinically significant. According to Grunwell (1982:89), it

indicates that "there are no incipient changes inherent in the child's system.". The primary aim of clinical intervention is to facilitate the establishment of new contrasts into a child's lexical system.

The main goal of phonological acquisition is the use of sounds contrastively to differentiate between meanings. The lack of contrasts in a child's speech may be due to a reduced phonetic inventory or an inefficient use of the potential for contrast in the inventory. In regard to the second factor, Grunwell (1980), for example, maintains that phonologically disordered children often fail to use the contrastive potential present in their phonetic inventories. That is to say, these children may simplify sounds and sound sequences in certain contexts, which in fact they can produce in other contexts. The reasons for the failure to maintain contrasts differ for each of the two factors. In regard to the small phonetic inventory, the lack of contrasts may result from production difficulties, whereas the inefficient use of the existing phones may indicate a cognitively based problem. The intervention strategies for these two factors would need to differ accordingly.

As has been indicated throughout this discussion, phonological processes reveal which phonological contrasts are neutralized in the speech of children. The Stopping of /s/ to [t], for instance, neutralizes the adult contrast between /s/ and /t/, which in turn implies that the child's lexical system may fail to differentiate between such word pairs as 'sin' vs. 'tin' or 'sip' vs. 'tip'. In other words, homophony results. It is not however only the 'systemic' processes (see above) which may produce homophony in the lexical system. The structural simplifications of Reduplication and Weak Syllable Deletion may also produce homophonous forms. This is also true for the processes with both structural and systemic consequences (e.g. Final Consonant Deletion and Cluster Reduction). Processes can produce two 'types' of homophony.

Type 1: The homophonous form produced is an acceptable word in the adult language. e.g. /spin/ → [pin] Cluster Reduction sp-p

Type 2: The homophonous form produced is not an acceptable word in the adult language. e.g. /bæt/ → [bæbæ] Reduplication of the first syllable

/bæk/ → [bæbæ]

These types of homophony can be produced both by processes operating one at a time on a word (i.e. single processes) or by more than one process operating at a time on a word (i.e. multiple processes).

Type 2 homophony can be further divided into two 'sub-types':

Type 2a: The homophonous form consists of contrastive phones of the adult language.

e.g. /sein/ → [tein] Stopping s-t
 /kein/ → [tein] Fronting k-t

Type 2b: The homophonous form consists of phones, which are either non-contrastive in the adult language or not part of the phonetic inventory of that language.

e.g. bottle → [boʔə] Note: The glottal stop may be contrastive in certain dialects of English, but not in the 'received pronunciation', which is the accent assumed for the present study.

grapes → [tʰɹɪːz] (from Grunwell, 1981)

The potential homophony predicted by the occurrence of phonological processes may not be always actualized (see also Chapter 4). Ingram (1975), for example, observed 'homophony avoidance' in his study of parental diaries of five normal children. The children were found to resort to two strategies to preserve surface contrast in their speech when homophony was predicted on the basis of their phonological rules. Surface forms were kept distinct

(i) by the use of alternative forms of pronunciation for one of the words in a potential homophonous pair

(ii) by idiosyncratic application of a variety of phonetic strategies not otherwise present in the child's system.

For example, the rules of one of the English speaking children in Ingram's study predicted the homophonous realization of [æ] for the words 'hat' and 'out'. However, the child produced [æʔ] for 'out' and [æ] only for the word 'hat'. Locke (1979) takes issue with Ingram by arguing that children cannot avoid homophony when in fact they seem to be unaware of the very errors which produce it. And furthermore, he found in his 'communicative failure' experiment, that children did not employ strategies to keep homophones separate, although they apparently knew that they were conflating different adult words. The issue of whether homophony avoidance is psychologically real or not

is not directly relevant for the present study. What is of relevance is that homophony predicted on the basis of processes may not be always realized (see Section 4.3 and Chapter 6, below).

The differing views on homophony avoidance may be partly due to the fact, that child realizations, which seem perceptually homophonous to an adult, may in fact be physically different (ie. non-homophonous to the child). Bernthal and Weiner (1976) found in their study of consonant omissions, that what appeared to be segment deletions were actually not complete omissions since spectographically discernible noise was detected in place of the omitted segment. Similarly, Macken and Barton's (1977) study on VOT (voice-onset-time) values of several young normal children showed that physical contrasts may be made by children, which are not perceptible to the adult listener. Phonetic progress (as measured spectographically) toward the adult VOT values was gradual in nature and much of this progress was within the phonemic boundaries observed by adult listeners. Locke (1979) also argues for the distinction between physical and perceptual homophony in child speech. He argues that since the English language does not contain many minimal pairs which differ only by one segmental feature, all segmental errors cannot conflate minimal pairs. For example, the deletion of /s/ in the word 'sweep' does not render it homophonous with the word 'weep', since /w/'s following /s/ are typically of greater duration than /w/'s preceded by silence. Therefore, the physical distinction between 'sweep' and 'weep' is maintained. It is highly unlikely, however, that this physical distinction, if maintained would be discerned by adult listeners. It may also be the case that the /w/ produced for 'sweep' acquires the phonetic characteristics of the /w/ which is typically preceded by a silence and as such there is 'true' homophony in regard 'sweep' and 'weep'.

The distinction between physical and perceptual differentiation of words in child speech is relevant to the management of phonological disorders. A child who makes a distinction between words sub-phonemically needs only to modify his behaviour in order to progress toward adult norms. On the other hand, a child who produces forms which are physically homophonous, needs to establish novel behaviour in order to be able to distinguish between meanings. In both cases, however, there is a need for intervention, since the

failure to signal meaning differences in speech in a manner which is perceptible to the listener calls for remedial attention.

The issue of potential versus actual homophony is also pertinent to the clinical context. It casts some doubt on the view that "the most obvious index of communicative adequacy is the actual and the potential occurrence of homophones resulting from a restricted system" (Grunwell, 1981:150). As was pointed out above, homophony predicted by phonological systems may not always become actualized. Furthermore, the role of actual homophony in 'real' communication remains still to be examined in detail (see Chapters 3 and 6). According to Priestly (1980), homophony in child speech cannot have much effect on communication in view of the narrowness of child vocabularies and the attendant rarity of contextually and grammatically appropriate minimal pairs in such vocabularies. Children are also likely to enter only fairly restricted and familiar communicative encounters. While this is most likely true of young normal children, which Priestly studied, children at older ages with disordered phonologies have reasonably extensive vocabularies and need to communicate in varying situations outside the immediate home environment. In such instances homophony may gain importance as a hindrance to adequate communication.

It seems reasonable to suppose that, if speech is to be intelligible, the number of homophones must be held to a tolerable level. What exactly a tolerable level entails is to be determined in relation to contextual and pragmatic factors which have bearing on communication. Meanwhile, however, the 'systemic' concept of homophony is applicable in the clinical context (see also Chapter 3). The principle aim of phonological therapy is to improve communicative adequacy of the phonological system by improving the contrastive power of that system. By establishing contrasts in the phonological system, the capacity of the lexical system to signal meaning differences improves by virtue of reduced levels of homophony present in that system. Thus, the determination of the extent to which the conflation of phonological contrasts affects the capacity of a child's lexical system to signal meaning differences would provide some principled guidelines for the

prioritization of treatment goals. Those contrasts which affect the system most appreciably would merit most urgent remedial attention. The next chapter arrives at a means of assessing the effect of missing contrasts in the phonological system on the capacity of that system to signal lexical differences.

Chapter 3: Assessing the Functional Adequacy of Children's Phonological Systems.

This chapter will examine how restricted phonological systems can be assessed in terms of their functional adequacy. The concept of functional adequacy is first defined with specific reference to the concept of communicative adequacy of phonological systems. Having defined functional adequacy the question as to whether the measures of functional load outlined in Section 2.1 would lend themselves to the assessment of functional adequacy is then considered. Specific attention will be paid to Connolly's (1986) use of a measure of functional load in gauging the number of functional distinctions left unsignalled by a linguistic system. In the light of these considerations a measure of functional loss (FLOSS) is proposed.

The function of the system of phonological contrasts is lexical differentiation. If we assume a lexical system or inventory (eg. a dictionary) which consists of lexical entries, the phonological system provides the only means for differentiating between these entries in terms of their form. The phonological system can thus be considered the sole differentiating force, when lexical items are considered separate from 'real' communication (see communicative adequacy, below). Functional adequacy of a phonological system can be operationally defined in reference to such a lexical system:

A functionally adequate phonological system
keeps lexical items apart in a lexical system.

A functionally inadequate system fails to do so, this failure being manifested as homophony in the system.

Functional adequacy of a phonological system is thus defined in system-based terms. The concepts of functional adequacy and inadequacy can be further examined by considering the following illustration. Let us assume that the phonological contrasts /*r* - *d*/ and /*t* - *d*/ are missing from a phonological system which is then reflected in the following manner in a lexical system:

Lexical System
(supported by a complete
phonological system)

Lexical System
(supported by an incomplete
phonological system - contrasts
tr - d, t - d missing)

$\left. \begin{array}{l} /trɪp/ \text{-----} /dɪp/ \\ /tɪp/ \text{-----} /dɪp/ \\ /dɪp/ \text{-----} /dɪp/ \end{array} \right\} \text{homophones}$

$\left. \begin{array}{l} /traɪ/ \text{-----} /daɪ/ \\ /daɪ/ \text{-----} /daɪ/ \end{array} \right\} \text{homophones}$

$\left. \begin{array}{l} /tru/ \text{-----} /du/ \\ /tu/ \text{-----} /du/ \\ /du/ \text{-----} /du/ \end{array} \right\} \text{homophones}$

$/tɪn/ \text{-----} /dɪn/$

It is apparent that the incomplete phonological system fails to distinguish between all the lexical items in the lexical system and as such can be considered functionally inadequate. This inadequacy is reflected in the realisation of the lexical targets 'trip', 'tip' and 'dip' by the homophone /dɪp/, 'try' and 'die' by /daɪ/ and 'true', 'too' and 'do' by /du/ in the lexical system. Lexical targets such as 'trip' and 'try', or 'tip' and 'too' are however kept apart by the phonological system. In other words, the fact that the contrasts 'tr - d' and 't - d' are missing from the system does not fail to signal the existence of a lexical distinction between these lexical targets. The absence of the phonological contrasts from the system has an effect on the signalling of the lexical distinctions 'trip' vs 'try' and 'tip vs 'too' to the extent that the distinction is not signalled by the phonological forms which are customarily used to signal the distinctions (ie. not /trɪp/ vs /traɪ/; /tɪp/ vs /tu/ but /dɪp/ vs /daɪ/; /dɪp/ vs /du/). While it is recognized that this kind of failure to signal lexical distinctions is indeed due to the phonological system functioning inadequately, it is maintained in this study that such failure is best examined in relation to what can be called the communicative adequacy of the phonological system (see below). It is thus maintained that a functionally adequate phonological system signals the existence of

lexical distinctions in a lexical system and failure to do so results in homophony.

As is indicated above, incomplete phonological systems can have two main effects on the lexical system:

- (1) The existence of lexical distinctions is not signalled, i.e. presence of homophony.
- (2) The existence of lexical distinctions is signalled but not in a manner customary to the ambient language.

In case of (1) the phonological system is clearly functioning inadequately: the existence of lexical distinctions is not signalled. In case of (2), however, there appear to be different 'degrees' of inadequacy which can be judged with reference to the relationship between the lexical target and the lexical realization. There appear to be three basic ways in which the lexical distinctions are not signalled in a manner customary to the ambient language (i.e. number (2), above):

- (1) Two lexical targets are realized by phonological forms which are used for the realization of other lexical targets:

e.g. 'trip' → /dɪp/ ('dip')
'trai' → /daɪ/ ('die')

- (2) Two lexical targets are realized by one phonological form which is used for the realization of another lexical target and by one phonological form which is not used for the realization of any other lexical items in the language:

e.g. 'trip' → /dɪp/ ('dip')
'top' → /dɒp/

- (3) Two lexical targets are realized by two phonological forms which are not used for the realization of any other lexical items in the language:

e.g. 'tractor' → /dæktə/
'task' → /dæsk/

The assessment of the adequacy of a phonological system which results in lexical patterns such as those exemplified in (1) - (3), would involve assessment of the relationship between the lexical targets and phonological realizations. Such assessment would involve judgments reflecting real communicative consequences of the actual realizations used for the targets. It would be highly likely that such consequences would differ for each of the relationships

reflected in (1) - (3). Note would need to be taken of the possibility of the items being able to occur in similar/same grammatical and pragmatic contexts, the auditory distance of the targets from their realizations (Line, 1987) and other such factors relevant to communication. It is apparent from this discussion that the type of inadequacy of the phonological system which is reflected by the presence of homophony is of a relatively uncomplicated nature, in that it indicates the total absence of the phonological function of lexical differentiation, by comparison with the communicative inadequacies entailed by the differentiation of lexical items by non-customary forms. The basic type of inadequacy resulting in homophony can be referred to as a systemic or functional inadequacy. If the adequacy of a phonological system is assessed by investigating the relationship of the target and its realization in 'real' communication, this could be referred to as an assessment of the communicative adequacy of the phonological system. While the investigation of communicative adequacy is the ultimate goal of a phonological analysis and assessment which aims to be clinically oriented, it would not be an easy task to perform such an analysis, so diverse are the variables affecting the adequacy of the phonological system in communication. How communicative adequacy could be measured is not pursued in any detail in the present thesis (but see Chapter 6, Section 6.1). The distinction between functional and communicative adequacy is summarized in Table 3.1 (overleaf).

As is apparent from Table 3.1 a functionally adequate phonological system is not necessarily a communicatively adequate one nor is a functionally inadequate system necessarily communicatively inadequate. In other words, a lexical distinction may be signalled in a manner which does not lead to effective communication of the intended meaning. On the other hand, homophony in the lexical system may not result in a communication failure. If the ultimate goal of the assessment of the adequacy of (children's) restricted phonological systems is indeed that of the assessment of communicative adequacy, what is the relevance of the assessment of functional adequacy? The assessment of functional adequacy provides a means of studying the effect of restricted phonological systems on the capacity of such a phonological system to signal lexical differences. It is then possible to determine whether the absence of certain phonological contrasts in the phonological system results in functional inadequacy and which of these lost contrasts result in the greatest inadequacy.

Table 3.1: Functional Adequacy vs Communicative Adequacy

Functional Adequacy: A phonological system is functionally adequate if it differentiates between lexical items in a lexical system.

e.g. 'key' vs 'tea'
/ki/ vs /ti/
'try' vs 'tie'
/tai/ vs /dai/

Functional Inadequacy: A phonological system is functionally inadequate if it fails to differentiate between lexical items in a lexical system which are customarily kept apart by the phonological system (ie. excluding conventional adult homophony, e.g.

'read' vs 'reed').

e.g. 'key' vs 'tea'
/ti/ vs /ti/
'try' vs 'tie'
/dai/ vs /dai/

Communicative Adequacy: A phonological system is communicatively adequate if it differentiates between lexical items in communication.

Communicative Inadequacy: A phonological system is communicatively inadequate if it fails to differentiate between lexical items in communication.

Since the phonological and lexical systems carry at least some of the 'responsibility' for adequate communication, the assessment of functional adequacy will tell us something about the potential consequences of restricted phonological systems. The more lexical distinctions that are left unsignalled the more chance for communicative failures. If we accept that the presence of homophony in language contributes towards communicative failure, (e.g. Connolly, 1980), then an assessment of functional adequacy would contribute toward an assessment of the communicative inadequacy of restricted phonological systems (see Section 6.1, below). As such, the assessment of functional adequacy may be viewed as a first step towards an assessment of communicative adequacy.

It must be noted, however, that an incomplete phonological system is not necessarily a functionally inadequate one as long as it keeps the lexical items apart in the lexical system which is its function to support. Thus, in relation to children's phonological systems, they are not necessarily functionally inadequate if they differ from adult systems of contrasts in that children's phonological systems do not need to support such a large lexical system as an adult phonological system does. The child is assumed to develop his own system of sound contrasts to signal his own lexical contrasts (e.g. Ferguson, 1978; Grunwell, 1981). Therefore, the assessment of functional adequacy should always be specific to a particular system. This in turn implies that it is not sufficient in the clinical context to identify the differences in the phonological systems of children and adults and then to facilitate a change in the child's system so that it will be more like the adults in order to promote the adequacy of the child's phonology to sustain sufficient communication (cf. Ingram, 1976; Grunwell, 1981, 1985).

It is maintained in the literature on clinical phonology that the main motivation for phonological assessment is to provide bases for improving the 'intelligibility' of the child's speech (e.g. Ingram, 1976; Grunwell, 1981; Hudson and Paden, 1983; Stoel-Gammon and Dunn, 1985; see also Section 6.1). Grunwell (1981, 1985) refers to the assesment of the communicative adequacy of restricted phonological systems in this connection. Grunwell's use of the term 'communicative adequacy' is essentially different from the concept of functional adequacy, but very similar to the concept of communicative adequacy introduced above. According to Grunwell (1985), factors which contribute to a child's phonological system being

communicatively inadequate include

- (i) multiple loss of phonological contrasts
- (ii) variability and overlap in phoneme realizations
- (iii) homophony
- (iv) absence of feature contrasts.

These factors are system-based indices of communicative inadequacy in that "the child's meanings have to be communicated to other speakers in the language community" (1985:36). The study of these factors in terms of the phonological system is assumed to indicate fairly directly the potential communicative inadequacy of restricted systems. It is maintained, for instance, that "where the child's system is smaller than the target system, which it almost invariably is, the communicative inadequacies of the child's system are succinctly revealed" (1985:39). It is thus apparent that a system-based analysis is assumed to reflect fairly directly the communicative inadequacies. This is the main difference between Grunwell's conception of communicative adequacy and the way in which the term is defined in the present study. It is maintained in this study that system-based indices of communicative adequacy may not in fact be very good indicators of the effect of a restricted phonological system on 'real' communication. For instance, it is not at all clear whether the homophony predicted by absence of contrasts in the system is realized in actual speech (cf. homophony avoidance, Section 2.2, above; see also Chapter 7, below) or whether the presence of homophony in a child's speech is in fact an important contributor to communicative failures. It may also be the case that certain systemic inadequacies reflect communicative inadequacy more directly than others and as such would need to be given due recognition in the assessment of the adequacy of phonological systems. For instance, there is some evidence that variability in phoneme realizations may affect the 'intelligibility' of children's speech more than the size of the contrastive system (Yavas, 1986). It still remains to be shown to what extent system-based indices reflect the ability of the listener to recover intended meanings (=communicative adequacy). Therefore, a clear distinction between functional and communicative adequacy is drawn in the present study.

It has been argued that the assessment of functional adequacy can provide some indication about the potential communicative consequences of restricted phonological systems. Such assessment

might also enable one to examine the potential effect of phonological factors on the growth of vocabulary. Furthermore, the assessment of functional adequacy might provide a means of testing whether children tend to acquire phonological contrasts in a manner which is least destructive to the functional adequacy of the phonological system. This in turn could provide the basis for an insightful comparison of linguistically normal and disordered children in their acquisition of phonological contrasts (see Chapters 6 and 7, further).

The question which must now be addressed is how to assess the functional adequacy of restricted phonological systems. The concept of functional load (see Section 2.1, above) provides the means of assessing the number of words differentiated in a lexical system by contrasts present in the phonological system. While the actual calculation of functional loads are generally considered to be based on frequency-of-occurrence of phonemes in texts rather than dictionaries (or lexical systems), the basic concept of functional load is applicable to the study of lexical systems. As is apparent from Section 2.1, the measure of functional load, whether conceptualized in terms of information theory or not, is based on probability of occurrence of phonemic contrasts in different environments. The basic feature of the calculations is to assess the number of minimal pairs distinguished by phonemic contrasts relative to the number of environments in which the phonemic contrasts could have contrasted. To look at this from the opposite point of view, the measures reveal the number of homophones that would result from the neutralization of contrasts relative to the number of potential homophones. If a phonemic contrast has a high probability of occurrence, (in texts or dictionaries), it will have high potential for homophony production if neutralized. However, this does not necessarily have to be so. Phonological contrasts can potentially occur in some environments without potential for homophony. As such, measures based on probability of occurrence are not very direct indices of homophony and consequently not good indicators of functional inadequacy. Furthermore, as was pointed out above, the assessment of functional adequacy is relative to a particular lexical system. Therefore there is no need to calculate probability of occurrence in order to carry out inter-system comparisons (see also below).

The basic idea of functional load does however enable one to assess the extent of homophony in a lexical system resulting from

restricted phonological systems. If we simply calculate the number of minimal pairs distinguished by a phonological contrast in a lexical system, by implication we have a measure of the number of homophones that would result in the lexical system if a contrast were absent. For instance, if we had a lexical system consisting of the items 'pit', 'pet', 'cap', 'pat' and 'paste', the following minimal pairs exist, if the contrast 'p - b' was considered: 'pit' vs 'bit', 'pet' vs 'bet', 'cap' vs 'cab', 'pat' vs 'bat' and 'paste' vs 'baste'. If these minimal pairs were present in the lexical system, they would become homophones if the contrast was missing from the phonological system:

e.g. LEXICAL SYSTEM:

/ pɪt / minimal pair
/ bɪt /

/ pet / " "
/ bet /

/ kæp / " "
/ kæb /

/ pæt / " "
/ bæt /

/ peɪst / " "
/ beɪst /

Thus, the concept of functional load enables one to assess the functional consequences of restricted phonological systems. It must be emphasized, however, that the concept of functional load is essentially a measure of complete phonological systems, and only by implication, can it be considered a measure of the consequences of a restricted phonological system (see the concept of functional loss, below).

Moreover, the measure of functional load (in terms of minimal pairs) is not an adequate indicator of the functional adequacy of a phonological system when more than one contrast is missing simultaneously from the phonological system. Let us assume that we want to examine the effect of the missing contrasts 'k - t' and 's - t' on the following lexical system:

e.g. $\left. \begin{array}{l} /kɪp/ \\ /tɪp/ \\ /sɪp/ \end{array} \right\} \text{minimal pair}$
 $\left. \begin{array}{l} /saɪt/ \\ /taɪt/ \end{array} \right\} \text{minimal pair}$
 $\left. \begin{array}{l} /kaɪt/ \\ /ki/ \\ /ti/ \end{array} \right\} \text{minimal pair}$

There are five minimally distinct lexical items that will be affected by the absence of the contrasts 'k - t' and 's - t' in the phonological system. This does not, however, reveal the full functional consequences of the two missing contrasts. The fact that the two contrasts consist of two identical phonemes (i.e. /t/) (see Chapter 4; Section 4.3.1.3) renders the words 'kip' vs 'sip' and 'sight' vs 'tight' also homophonous (or minimally distinct). Thus, it is not adequate to consider only the number of lexical distinctions signalled by contrasts in a lexical system; it is also necessary to consider how these contrasts interact (see Chapter 4). Existing approaches to functional load have not considered such interactions simply because functional load has been defined as a measure of "the amount of work" done by each phonological contrast present in the system in keeping lexical items apart. The importance of interacting contrasts emerges only when we want to study the functional consequences of contrasts being absent from the phonological systems, i.e. when we want to investigate the resultant homophony directly. As such, the concept of functional load is too narrowly defined for the assessment of the functional adequacy of restricted phonological systems. (cf. the concept of functional loss (FLOSS), below).

We must now ask whether the concept of functional load can be utilized in a measure of functional inadequacy, even though it is not directly relevant to such assessment. It may be possible to calculate the functional load of the whole phonological system in terms of the number of lexical distinctions it serves to distinguish in a lexical system. With this aim in mind, Connolly (1986) proposed a means of measuring the functional consequences of restricted linguistic (including phonological) systems (see Section 2.1). This measure consists of the calculation of the number of

lexical distinctions signalled by complete and incomplete phonological systems.

e.g. (1)

LEXICAL SYSTEM		LEXICAL SYSTEM	
(complete phonological system)		(incomplete phonological system)	
/kɪp/	-----	/dɪp/	} /dɪp/
/tɪp/	-----	/dɪp/	
/dɪp/	-----	/dɪp/	
/tɪp/	-----	/dɪp/	
/kɪk/	-----	/dɪk/	} /dɪk/
/tɪk/	-----	/dɪk/	

Assuming that the phonological contrasts /k, d/, /t, d/ and /tr, d/, were missing, then according to Connolly's formula, the complete phonological system signals 15 lexical distinctions and the incomplete one signals 1 lexical distinction. The ratio of $1 \div 15$ then indicates that the capacity of the lexical system to signal lexical distinctions is reduced by 93.3%. In this fashion, it is possible to compare the effects of incomplete phonological systems on the lexical system.

What is meant by the statement that the incomplete phonological system can signal only one lexical distinction in the above example? It obviously cannot refer to the signalling of any of the lexical distinctions signalled by the lexical system supported by the complete phonological system. It appears to refer to the presence of one minimal pair in the restricted system which is assumed to signal one lexical distinction, but it is not clear what this distinction is. This measure fails to reflect the presence of homophony. However the ratio does reveal the presence of homophony and thus to a certain extent reflects functional inadequacy of the phonological system. Nevertheless the formulae and resultant measures proposed by Connolly do not measure functional inadequacy as it is defined in the present study. This can be illustrated by the following example: let us assume a complete phonological system which differentiates between the following lexical items: /kɪp/, /tɪp/, /dɪp/, /kɪk/, /tɪk/ and /dɪk/. As in the above example (i.e., e.g.(1)) the functional load of the system is 15 (N = 6). If the phonological

system was rendered incomplete so that the contrasts $/k, d/$ and $/t, d/$ were missing in the WI-position, the functional load of the reduced system would be 1.

e.g. (2)

$/kɪp/$	-----	$/dɪp/$	} $/dɪp/$
$/tɪp/$	-----	$/dɪp/$	
$/dɪp/$	-----	$/dɪp/$	
$/kɪk/$	-----	$/dɪk/$	
$/tɪk/$	-----	$/dɪk/$	$/dɪk/$
$/dɪk/$	-----	$/dɪk/$	

The ratio of 0.07 can be then calculated using Connolly's formula to reflect the extent of reduction in the capacity of the incomplete phonological system to signal lexical differences.

According to the ratios produced on the basis of Connolly's formula for the above two examples (e.g.(1) and (2)), the same number of functional distinctions are left unsignalled. But, the two lexical systems supported by the two different incomplete phonological systems cannot in fact signal the existence of the same number of lexical distinctions. While it is true that both of these lexical systems consist of two phonological forms, the manner in which these forms relate to the lexical targets which they serve to signal differs for the two examples. And it is this difference which must be taken into account in the assessment of functional adequacy of phonological systems. In e.g. (1) the number of distinctions left unsignalled is 7, while the corresponding value for e.g. (2) is 6. This difference is reflected in the number of lexical targets each homophonous form represents. In e.g. (1) the homophonous form $/dɪk/$ corresponds to four lexical targets and the form $/dɪp/$ corresponds to two lexical targets. Therefore, the phonological system fails to signal the existence of $6 + 1 (=7)$ lexical distinctions. In contrast, in e.g. (2) the homophonous form $/dɪp/$ corresponds to three lexical targets and the homophonous form $/dɪk/$ corresponds also to three lexical targets. Thus, this phonological system fails to signal the existence of $3 + 3 (=6)$ lexical distinctions.

The apparent failure of Connolly's measure to capture the functional consequences of restricted phonological systems can be further illustrated by the following schematic example:

LEXICAL SYSTEM A

complete
phonological
system

A }
B }

C }
D }

E }
F }

G }
H }

I }
J }

K }
L }

M }
N }

O -

incomplete
phonological
system

A

D

F

H

J

L

N

O

LEXICAL SYSTEM B

complete
phonological
system

A }
B }
C }
D }
E }

F }
G }
H }

I }
J }

K -

L -

M -

N -

O -

incomplete
phonological
system

A

H

J

K

L

M

N

O

LEXICAL SYSTEM A:

(i) Complete Phonological System:

N = 15

C_c = 105 (=Functional Load)

(ii) Incomplete Phonological System:

N = 8

C_I = 28 (=Functional Load)

$$\approx \frac{C_I}{C_c} = 0.27 ; 27\%$$

Number of lexical distinctions left unsignalled : 7

LEXICAL SYSTEM B:

(i) Complete Phonological System:

$$N = 15$$

$$C_c = 105 (= \text{Functional Load})$$

(ii) Incomplete Phonological System:

$$N = 8$$

$$C_I = 28$$

$$\approx \frac{C_I}{C_c} = 0.27 ; 27\%$$

Number of lexical distinctions left unsignalled : 14

(See the measure of FLOSS, below, for how the number of lexical distinctions unsignalled is calculated.)

While it must be recognized that this example is somewhat unrealistic, especially in relation to child phonology, it does capture the essence of the problem with Connolly's measure: that is, it does not calculate the functional adequacy of phonological systems by reference to the lexical systems they support. In other words, Connolly's measure operates with the implicit assumption that an incomplete phonological system does not attempt to signal the same lexical distinctions that are signalled by the complete phonological system. As has been indicated above, this is clearly not so. In relation to the two examples (e.g. (1) and (2), above) it is now apparent that the lexical system supported by an incomplete phonological system does not contain only one lexical distinction, but rather these lexical systems contain 8 (e.g. (1)) and 9 (e.g. (2)) lexical distinctions.

i.e. e.g. (1)

- /dɪp/ vs /dɪk/ can signal the following lexical distinctions:

/kɪp/ vs /tɪk/; /kɪp/ vs /dɪk/;

/tɪp/ vs /tɪk/; /tɪp/ vs /dɪk/;

/dɪp/ vs /tɪk/; /dɪp/ vs /dɪk/;

/kɪk/ vs /tɪk/; /kɪk/ vs /dɪk/;

e.g. (2)

- /dɪp/ vs /dɪk/ can signal the following lexical distinctions:

/kɪp/ vs /kɪk/; /kɪp/ vs /tɪk/;

/kɪp/ vs /dɪk/; /tɪp/ vs /kɪk/;

/tɪp/ vs /tɪk/; /tɪp/ vs /dɪk/;

/dɪp/ vs /kɪk/; /dɪp/ vs /tɪk/;

/dɪp/ vs /dɪk/.

It is apparent from the discussion thus far that in order to assess the functional adequacy of restricted phonological systems a measure which gauges the number of lexical distinctions left unsignalled in a lexical system is required. Furthermore, such a measure would ideally enable one to assess functional adequacy directly, without the need for first positing an existence of a complete phonological system and then assuming the system incomplete. The concept and measure of functional loss (FLOSS) has been formulated as a direct measure of the functional adequacy of incomplete phonological systems. More specifically, FLOSS reflects the number of homophonous pairs in a lexical system resulting from the absence of contrasts in the phonological system. The concept of homophonous pair has been proposed in the literature on child phonology (Ingram, 1975; 1985), but it has not as yet been clearly defined. A homophonous pair can be said to consist of two homophonous types which share the same homophonous form.

e.g. $\left. \begin{array}{l} /tɹɪp/ \\ /tɪp/ \end{array} \right\} /tɪp/$

- $/tɹɪp/$ and $/tɪp/$ form a homophonous pair.

From the discussion of Connolly's measure above, it is now clear how homophonous pairs indeed enable the assessment of FLOSS. This can be illustrated by the following example:

e.g. The contrasts $/tɹ, d/$ and $/t, d/$ are missing from the phonological system.

LEXICAL SYSTEM (Complete phonological system)	LEXICAL SYSTEM (Incomplete phonological system)
$/tɹɪp/$	$/dɪp/$
$/tɪp/$	$/dɪp/$
$/dɪp/$	$/dɪp/$
$/tɹaɪ/$	$/daɪ/$
$/tɪaɪ/$	$/daɪ/$
$/dɪaɪ/$	$/daɪ/$
$/tɹu/$	$/du/$
$/dɹu/$	$/du/$
$/tɹɪn/$	$/dɪn/$
$/tɹəʊ/$	$/dəʊ/$

The number of lexical distinctions left unsignalled by the incomplete phonological system (i.e. the FLOSS in the phonological system) is 7. In other words, there are 7 homophonous pairs in this sample. The following lexical distinctions are left unsignalled (=homophonous pairs):

/tɹɪp/ vs /tɪp/
 /tɹɪp/ vs /dɪp/
 /tɪp/ vs /dɪp/
 /tɹaɪ/ vs /tʰaɪ/
 /tɹaɪ/ vs /daɪ/
 /tʰaɪ/ vs /daɪ/
 /tu/ vs /du/

As is apparent, the measure of FLOSS relates the homophonous forms produced to their lexical targets and therefore avoids the major problem of Connolly's measure of 'functional load'.

FLOSS is thus a direct measure of incomplete phonological systems, while functional load is a measure of complete phonological systems. While FLOSS in the present study operates as a system-based concept (analysis based on lexical systems rather than texts in communication), the underlying concept of homophony which is central to the concept of FLOSS, renders it also applicable to the study of the communicative consequences of incomplete phonological systems. A phonological contrast is communicatively important if words or utterances are left undifferentiated in communication when it is absent from the phonological system. One probable contribution to this communicative failure is homophony (see also communicative adequacy, above; and Chapter 6). As such, this aspect of communicative adequacy can be measured by FLOSS. Communicative importance is not, however, the domain of functional load, which measures the number of words or utterances differentiated by contrasts present in the phonological system.

FLOSS is the measure of the functional adequacy of restricted phonological systems. The FLOSS-value of zero indicates that the phonological system is functionally adequate in regard^{to} the lexical system which it supports (see above), thus the higher the FLOSS-value, the more inadequate the phonological system. However, it has to be recognised that functionally inadequate phonological systems with the same FLOSS-values, may not have equal destructive potential for communication. One aspect of this potential insensitivity in the measure of FLOSS can be illustrated by the following two examples:

problematic in relation to e.g. (3) rather than e.g.(4) in that all the undifferentiated lexical distinctions are realized by the same phonemic form. This is an instance of multiple homophony. Multiple homophony occurs when one homophonous form corresponds to more than two lexical targets (= two homophonous types; Ingram, 1975). It can thus be hypothesized that the occurrence of multiple homophony in the lexical system indicates a greater potential for communicative inadequacy. Thus, as a step toward making the assessment of the functional adequacy of restricted phonological systems more 'communicatively' oriented, an index of multiple homophony (IMH) is introduced into the assessment of functional adequacy. The index of IMH is obtained as a ratio of homophonous types to homophonous forms. In reference to the above two examples, the following IMH are obtained:

e.g. (3): 5:1

e.g. (4): 2:1

This information then captures the potential for different communicative consequences of the two phonological systems. Whether the hypothesis about the potential relationship between multiple homophony and communicative failures will hold in reality needs to be tested in experiments of the "real" communicative adequacy of phonological systems. This is beyond the scope of the present study.

The assessment of the functional inadequacy of phonological systems in terms of FLOSS and IMH can only be calculated with reference to a particular lexical system (or sample). That is, such assessment is always data-specific. Therefore, the assessment does not lend itself to the comparison of one set of FLOSS-values or IMH with another set. For instance, it would not be informative to measure FLOSS in relation^{to} the number of words affected and use this as a comparative measure between samples, since FLOSS is relative to a specific sample. If the absence of a contrast produced 2 homophonous pairs out of ten affected lexical items ($2/10 = 0.2$) in one lexical sample of children's vocabulary and 2 out of 2 ($2/2 = 1.0$) in another sample, it is meaningless to suggest that one is more characteristic of FLOSS in children's vocabularies than the other. If, however, we attempted to maintain that a particular set of FLOSS-values (or IMH) reflect the functional inadequacy of the phonological system of an 'average' child (i.e. calculated on the basis of 'common' vocabulary of children; see Section 5.1), then the

adequacy of the values would have to be determined in relation to the representativeness of the sample.

It is similarly not relevant to consider the ratios of homophonous pairs to all possible homophonous pairs for different lexical samples either. If the ratios 2/10 and 2/2 were produced when two phonological contrasts were absent (say, /t̥,d/ and /p,b/), all we would be able to say is that /p,b/ had the opportunity to produce homophony more than the contrast /t̥,d/ in that sample. But this does not indicate that the loss of the contrast /p,b/ is necessarily more destructive to the functional adequacy of the phonological system. For this to be so, the lexical sample would have to consist of all the lexical items consisting of the phonemes /p/ and /b/ in children's vocabularies. It is of course impossible to determine which lexical items consisting of the phonemes /p/ and /b/ are part of children's vocabularies. Such ratios could, however, gain some interest in relation to the calculation of FLOSS on the basis of adult dictionaries, but then it is unlikely that one would want to assess the functional adequacy of restricted phonological systems on such a basis. Values produced on such bases would be of theoretical interest only, while the measure of FLOSS is essentially developed with an applied motivation.

The clinical relevance of the concepts of FLOSS and multiple homophony is evident. They enable the assessment of the functional inadequacy of incomplete phonological systems. The phonological systems of linguistically disordered children may indeed be contrastively inadequate. If, therefore, FLOSS-values and IMH were calculated for those phonological contrasts commonly found to be missing from the phonological systems of such children on the basis of a 'representative' lexical sample (see Chapter 5), we would have a means of determining the hypothesized relative effects of the loss of contrasts for the functional adequacy of phonological systems of such children. This, in turn, could be considered of some value in the prioritization of treatment goals in therapy which aims at the elimination of homophony in children's lexical systems. Those contrasts with the highest FLOSS-values and IMH would merit more urgent clinical attention. Such principled treatment planning may also be beneficial for improving the communicative abilities of such children insofar as the phonological and lexical systems are credited some importance in communication (see Chapters 6 and 7). The apparent relevance of FLOSS and multiple homophony for treatment

planning parallels earlier suggestions by a number of authorities in relation to the concept of Functional Load (e.g. Beresford and Grady, 1968; Haas, 1968; Connolly, 1980). These researchers maintained that if we can calculate the relative importance of phonological contrasts in keeping words apart in lexical systems and/or texts, (i.e. Functional Load), then, by implication, we can determine which contrasts would merit priority in treatment if they were missing and resulted in homophony.

The concepts of FLOSS and multiple homophony gain further relevance in the clinical context if the absence of phonological contrasts from children's phonological systems is correlated with the occurrence of phonological processes (Stampe, 1979; see also Section 2.2). For instance, the process of Fronting of 'k - t' (where (/k/ becomes [t])) is operative in child realizations such as [kɪ] for /tɪ/ and [mɛt] for /mæk/. This, in turn, implies that the contrast /k, t/ is absent from the phonological system. The term 'phonological process' is generally used for groups of sound patterns with similar characteristics. For example, the process of Fronting usually describes the changing of /k/ to [t], /g/ to [d] and /ŋ/ to /n/. In the present study the term 'phonological process' is used to refer to each sound change within each "process" category. Thus, Fronting is referred to as a process category and the individual Fronting of 'k - t', 'g - d' and 'ŋ - n' as processes within this category (see Chapter 5 and Chapter 6). Since children's phonological patterns are often described in terms of the framework of process analysis (e.g. Ingram, 1976, 1981; Hodson, 1980; Shriberg and Kwiatkowski, 1981; Grunwell 1985) (see Section 5.2.1 and Section 6.1), calculation of FLOSS-values and IMH for common phonological processes found in the speech of phonologically disordered children would promote wider applicability for the present study.

The concepts of FLOSS and multiple homophony are applicable to the study of any restricted phonological system, even though the emphasis of the present study is on the clinical population of phonologically disordered children. Furthermore, a calculation of FLOSS-values and IMH can be considered potentially relevant in the study of normal child phonologies. For instance, it would be possible to evaluate on the basis of such values whether FLOSS and multiple homophony correlate with the order and progress of phonological change in developing phonological systems. For example,

we could investigate whether there is evidence for the development of contrasts with high FLOSS-values before those with low FLOSS-values. Issues such as this will be considered further in Chapter 7.

The concepts of FLOSS and multiple homophony have been introduced in this chapter to provide a means of measuring the functional adequacy of restricted phonological systems. It is maintained that functional inadequacy reflects contrastive inadequacy and is measured in relation to a lexical system. Furthermore, such contrastive inadequacy can be described in terms of phonological processes. In the description of child speech, it is highly likely that more than one process at a time operates on a word (e.g. /tʃɪp/ → [dɪp]; WI Cluster Reduction and Prevocalic Voicing) (e.g. Ingram, 1976; Grunwell, 1982; Edwards and Shriberg, 1983; Stoel-Gammon and Dunn, 1985). The next chapter considers such combinations of processes in relation to the assessment of functional adequacy. Particular emphasis is laid on the ordering of processes in combinations and the relationships of such orderings to FLOSS and multiple homophony.

Chapter 4 : Ordering of Phonological Processes

The purpose of this chapter is to examine the notion of rule ordering in relation to the phonological process analysis in the assessment of the functional adequacy of children's phonological systems. Some of the main issues in the ordering of phonological rules in general are first overviewed. Then the notion of rule ordering in child phonology is briefly examined. These two subsections provide the background for the consideration of the ordering of phonological processes in the assessment of functional adequacy.

4.1 General Issues in the Ordering of Phonological Rules

The ordering of phonological rules (hereafter PRs) is central to generative phonology (Chomsky and Halle, 1968). PRs convert abstract underlying representations in a language to surface representations. This is done in such a fashion as to capture phonological generalizations in the language and in languages in general. For instance, in English the PR

$$v \rightarrow \tilde{v} / \text{---} [_{+nasal}]$$

which states that vowels become nasalized before nasal consonants captures the structural relatedness of such surface realizations as [kẽnt], [mĩn] and [sĩn]. In addition to PRs being used for the description of languages per se and for the reflection of universal tendencies in languages, PRs are also useful in capturing sound change over time (e.g. Kiparsky, 1968) or in comparing different dialects with one another (e.g. Hyman, 1975).

PRs can be viewed as possessing certain properties. For instance, PRs can be context-sensitive or context-free (cf. Chapter 5, Section 5.2.1), obligatory or optional, opaque or transparent (see Sommerstein, 1977). A characteristic which is of main importance for the present study is that of ordering. In any phonological analysis there appear to be rules which need to be ordered in order to generate particular surface structures. This can be illustrated by an example given by Hyman (1975:31) (originally cited by Chomsky, 1964) of two dialects of American English which exhibit certain

surface differences describable only in terms of the order in which particular rules apply. In one of these dialects (Dialect A) the words 'writer' and 'rider' are both pronounced as [ra:ɪfə], while in the other dialect (Dialect B) 'writer' is pronounced as [raɪfə] and 'rider' as [ra:ɪfə]. According to generative phonology these surface forms can be derived from the underlying representations of /raitə/ ('writer') and /raidə/ ('rider') by two PRs viz. Vowel Lengthening and Flapping. As is apparent from the following illustration, the application of the two rules in opposite orders is critical to the description of the differing surface forms for the two dialects:

Rule 1: V → V: /___ [+voice]

Rule 2: $\left\{ \begin{matrix} t \\ d \end{matrix} \right\} \rightarrow \text{ɾ} / V_V$

raitə	raidə	Dialect A	Dialect B
raɪfə	raɪfə	Rule 2	
ra:ɪfə	ra:ɪfə	Rule 1	
	ra:ɪdə		Rule 1
raɪfə	ra:ɪfə		Rule 2

While ordering constraints are indeed part of a generative phonological theory, several types of rule ordering constraints have been hypothesized. These range from the linear ordering hypothesis of the standard transformational theory (i.e. Chomsky and Halle, 1968) to several types of iterative application of rules (see Sommerstein, 1977:171-174). The ordering constraints are simply different ways of describing the manner in which the concept of rule ordering can be incorporated into a linguistic theory and as such are of no crucial importance for the present study (see Section 4.3, below). Similarly, the issue of whether rules are intrinsically or extrinsically ordered in a grammar is of no real concern for the present study. We shall simply note that the arguments for (e.g. King, 1976; Vago, 1977; Noske, Schinkel and Smith, 1982) and against (e.g. Cole, 1972; Ringen, 1972; Lehman, 1972; Koutsoudas, 1972, 1980; Koutsoudas, Sanders and Noll, 1978) language-specific (i.e.

extrinsic) ordering constraints in a phonological theory have not resulted in any conclusion in regard to this issue.

What, however, is of major relevance for the present study are the different types of ordering relationships which may hold between PRs. These relationships depend on potential or actual interaction (or interference, Chafe, 1967) between two rules. Absence of such interaction entails random or simultaneous ordering of rules. Whether the potential interaction is actualized is determined in relation to the phonetic output of the rules.

The conditions under which interaction is present can be stated explicitly and precisely though these conditions vary for different types of interaction. Two main types have been recognized viz. additive and subtractive interference (Chafe, 1967) or feeding and bleeding relationships in Kiparsky's (1968) terms. Interference is additive, or a feeding relationship exists, when the output of Rule A creates new input for Rule B. Interference is subtractive, or a bleeding relationship exists, when Rule A removes some input from Rule B. However, the specific manifestation of interaction becomes more apparent if the conditions for the relationships are stated in more precise terms. Following Chafe (1967:120) additive interference exists when the respective rules satisfy the following three conditions:

- (1) The output of Rule A overlaps with the structural description (SD) of Rule B.
- (2) The addition of the environment of Rule A does not destroy the overlap.
- (3) The substitution of the input of Rule A for the output of Rule A destroys the overlap.

To illustrate these conditions we can take an example from two known rules in child phonology.

Rule A : $k \rightarrow t / \# ___$

Rule B : $t \rightarrow d / \# ___$

Rules A and B are additive (or a feeding relationship exists between them) in that they satisfy the above three conditions:

- (1) - Output of Rule A: t
- SD of Rule B: $\#t$

- Overlap with the output of Rule A and the SD of Rule B maintained (i.e. $t, \#t$)
- (2) - Output of Rule A + environment: $\#t$
 - Overlap with the SD of Rule B still exists (i.e. $\#t, \#t$)
- (3) - Input of Rule A: k
 - Overlap with the SD of Rule B is destroyed (i.e. $k, \#t$)

In a similar fashion Chafe outlines three conditions for the existence of subtractive interference:

- (1) The input of Rule A overlaps with the SD of Rule B
- (2) The addition of the environment of Rule A does not destroy the overlap.
- (3) The substitution of the output of Rule A for the input of Rule A destroys the overlap.

Again these conditions can be illustrated with an example from child phonology:

Rule A: $s \rightarrow f / \# _ w$

Rule B: $s \rightarrow 0 / \# _ C$

(Rules from Edwards and Shriberg, 1983:307)

Rule A is subtractive with respect to Rule B (or Rule A bleeds Rule B) in that they satisfy the above three conditions:

- (1) - The input of Rule A: s
 - The SD of Rule B: $\#sC$
 - Overlap with the input of Rule A and the SD of Rule B exists (i.e. $s, \#sC$)
- (2) - Input of Rule A and its environment: $\#sw$
 - Overlap with the SD of Rule B still exists (i.e. $\#sw, \#sC$)
- (3) - Output of Rule A: $\#fw$
 - = Overlap with the SD of Rule B is destroyed (i.e. $\#fw, \#sC$)

As the examples clearly show the function of the three conditions for both additive (i.e. feeding) and subtractive (i.e. bleeding) interference is to ensure that ...

- Condition 1. ... the input or the output of Rule A is relevant for the operation of Rule B. For additive interference, the output needs to be relevant in order to provide new input for Rule B. In regard to subtractive interference, the input of Rule A overlaps

with Rule B so as to reduce the instances available for Rule B to operate (i.e. The input of Rule A is a specific instance of the SD of Rule B.)

- Condition 2. ... the two rules are not in complementary distribution; i.e. do not operate in different contexts
- Condition 3. ... Rule A "makes a significant difference in the applicability of" Rule B (Chafe, 1967:123). This is best illustrated by considering an example which fails to satisfy Condition 3.

Rule A: $k \rightarrow t / \# \underline{\quad}$

Rule B: $S \rightarrow d / \# \underline{\quad}$

(S = stop consonant)

The input of Rule A does not destroy the overlap with the SD of Rule B, and as such the existence of Rule A makes no contribution to the outcome of the rules. Rule A is irrelevant to the operation of Rule B in that the input and output are both specified by the input to Rule B.

On the basis of the conditions outlined by Chafe, it is possible to determine whether two rules interfere (or interact) and the nature of this interaction. However, the relationships established in such a fashion do not necessarily imply an ordering relationship. Ordering relationships can only be determined by reference to the phonetic output of the rules i.e. data. In Chafe's terminology, if potential interference is actualized Rule A is either appropriately additive or subtractive with respect to Rule B. If, on the other hand, potential interference is not actualized the rules are said to be inappropriately additive or subtractive. It thus follows that a rule which is appropriately additive or subtractive in respect another rule is ordered prior the other rule.

While in relation to real data two rules are always asymmetric as regards interaction in the sense that the relationship exists only in one direction (i.e. unidirectional), Chafe points out that in theory subtractive interference may be symmetric (i.e. bidirectional) in some instances. He gives the following example from Caddo (p. 124):

Rule A: $kw \rightarrow p$

Rule B: $k \rightarrow h / \underline{\quad} C$

It is evident that subtractive interference can be symmetric in

regard these two rules. In other words, the relationship exists irrespective of the order in which the two rules operate. The output of the subtractive relationship however differs for the two orders. In reference to data from Caddo, Rule A is appropriately subtractive with regard to Rule B.

It is also pointed out by Chafe that asymmetrical subtractive interference is in fact always appropriate. That is to say that there is no need to have recourse to data to determine the ordering in such a relationship provided that we accept the condition that no phonological rule is vacuous. In the following example,

Rule A: $s \rightarrow f$ /#__w

Rule B: $s \rightarrow \emptyset$ /#__C

Rule B can not be ordered before Rule A, since there could not be any instances in the data to necessitate the combination of these two rules in the first place. Since the SD of Rule A is included in Rule B, it becomes vacuous if Rule B precedes it. In Chafe's terminology, subtractive interference is self-ordering.

Parallel to Chafe's term inappropriate additive interference is Newton's (1971) term counter feeding. This entails the opposite ordering to a feeding relationship and as such is not an interactive relationship. If the target /kɪp/ was realized as [dɪp], /kait/ as [dait] and /tait/ as [dait], the relationships existing between the targets and realizations could be described in terms of the following two rules operating in a feeding order:

Rule A: $k \rightarrow t$ /#__

Rule B: $t \rightarrow d$ /#__

A counter feeding relationship, on the other hand, would be evidenced by the realizations [tɪp] for /kɪp/, [tait] for /kait/ and [dait] for /tait/, where the rules have to apply in the following order:

Rule B: $t \rightarrow d$ /#__

Rule A: $k \rightarrow t$ /#__

Newton also introduces the term counter bleeding. A counter bleeding relationship may or may not be the opposite ordering to bleeding depending on how a bleeding relationship is defined. There appear to be two different types of bleeding; these differ in terms of the bleeding agent. In Chafe's definition of subtractive interference, the bleeding relationship is manifested through phonological segments:

Rule A: $s \rightarrow f$ /#___w

Rule B: $s \rightarrow \emptyset$ /#___C

Bleeding is manifested through the inputs of the two rules (i.e. segment /s/ and through the fact that the SD of Rule A is totally included in Rule B). The opposite ordering to this bleeding relationship produces an absolute bleeding relationship (Hyman, 1975), in which Rule B, if ordered first, removes all the input to Rule A. viz. Rule A becomes vacuous. Thus, no 'counter bleeding' relationship exists. This will be referred to as Segmental Bleeding in the present study.

The second type of bleeding relationship, on the other hand, is manifested through phonological environments, which define the operation of the two respective rules. Newton's (1971:32) example from Greek of a bleeding relationship falls within this type.

Rule A: /i/ , /u/ $\rightarrow \emptyset$ / unstressed

Rule B: velar C $\rightarrow$ palataliz. C /___ front V

Rule a 'bleeds' Rule B through the environment of /i/. These rules operate in fact in an opposite order to the bleeding relationship in northern Greek. The precedence of Rule B over Rule A enables an unrestricted operation of both rules. Newton refers to this order as 'counter bleeding' since "the order is such that the bleeding possibility is not exploited" (p.32). As such, bleeding through an environment is different from bleeding through phonological segments in that the rules can apply in an opposite order to the bleeding relationship. This will be referred to as Contextual Bleeding in the present study.

Two rules can be said to enter a counter bleeding relationship, if in the opposite order one would remove input from the other (i.e. bleed). The question is whether this also refers to instances where the opposite order removes all the input from the other rule. In other words, is there such a concept as 'counter bleeding to absolute bleeding'? The term counter bleeding has indeed been used in reference to such instances. Edwards and Shriberg (1983:302) give the following example from child phonology:

Rule A: $d \rightarrow g$ /___Vg#

Rule B: $g \rightarrow \emptyset$ /___#

Interaction of these rules is through environment (cf. Contextual Bleeding). If Rule B preceded Rule A, it would absolutely bleed Rule

A. The order in which Rule A precedes Rule B, on the other hand, would enable an unrestricted operation of the two rules. As such, the order Rule A before Rule B can be considered counter bleeding order. It needs to be noted, however, that a Segmental Bleeding relationship is not a counter bleeding relationship even though the opposite order to it produces an absolute bleeding relationship. This is because a 'bleeding' relationship exists between the two rules rather than the two rules operating in an unrestricted way, as is the case in counter-bleeding. While the distinction between the two types of bleeding has not been made in the literature, it appears a valid one in that it explains why counter bleeding is not necessarily the opposite of bleeding; it is only the opposite of Contextual Bleeding (see Table 4.1, overleaf).

Throughout this section the potential relationships existing between rules have been referred to as ordering relationships, which implies that they describe non-random sequential application of rules. While it is not necessary for the present study to discuss in any detail whether rules in a grammar are simultaneously or sequentially ordered, a few informal observations can be made. If we accept that rules tend to apply maximally (e.g. Kiparsky, 1968; Fischer - Jorgensen, 1968) then a feeding relationship could be considered an iterative sequential application of rules in random order. In other words, a rule would apply every time its structural description is met. As such, a feeding relationship is considered natural or unmarked. For rules to apply in any other way, ordering constraints would be imposed. Thus, counter feeding is considered an ordering relationship proper and as such is a marked relationship. Using the same rationale, counter bleeding would then be an unmarked relationship, in that such rules can apply maximally. Bleeding relationship would be a marked ordering relationship. On the other hand, if we consider phonological rules separately from a theory of grammar, we can maintain that Segmental Bleeding and Counter-bleeding to Absolute Contextual Bleeding can be considered self-ordering, in that if two rules exist there is only one possible way to order the two rules, if they are both to be operable. In contrast, feeding, counter feeding, Contextual Bleeding and Counter - Bleeding to Contextual Bleeding can be considered as

Table 4.1: Types of Ordering Relationships and Their Opposite Orders

Type of Relationship	Opposite Order
Feeding	Counter Feeding
Segmental- Bleeding	(*) Absolute Bleeding
Contextual- Bleeding	Counter Bleeding to Contextual-Bleeding
(*) Absolute Contextual- Bleeding	Counter Bleeding to Absolute Contextual- Bleeding

(*) Not an ordering relationship; Results in a vacuous rule.

ordering relationships proper in that data must be consulted to determine the existence of these relationships.

In this section some general issues in the ordering of phonological rules have been overviewed. This overview is essentially selective, examining in particular the different types of interactive relationships into which phonological rules can be observed to enter. In the next section, the role of the ordering of phonological rules in child phonology is examined. The relevance of these two sections for the present study will become apparent in Section 4.3.

4.2 Ordering of Phonological Rules or Processes in Child Phonology

Phonological rules or processes are widely used in the description of speech patterns of both phonologically normal (e.g. Smith, 1973; Salus and Salus, 1974; Ingram, 1976; Stampe, 1979) and disordered (e.g. Applegate, 1961; Compton, 1970; Oller, 1973; Ingram, 1976; Grunwell, 1981) children (see Chapter 2; Section 2.2). It is also generally agreed that in order to describe adequately these data PRs or processes need sometimes be ordered (e.g. Applegate, 1961; Compton, 1970; Oller, 1973; Smith, 1973; Salus and Salus, 1974; Stampe, 1979; Kiparsky and Menn, 1977; Grunwell, 1982; Edwards and Shriberg, 1983; Stoel-Gammon and Dunn, 1985). However, there is some indecision as to the status of rules or processes, and consequently of the postulated rule ordering constraints.

Some investigators consider the PRs or processes evident in child speech psychologically real, reflecting innate acquisitional strategies employed by a child in mastering the phonological system (e.g. Smith, 1973; Salus and Salus, 1974; Ingram, 1976; Kiparsky and Menn, 1977; Stampe, 1979). Some others, on the other hand, consider PRs or processes as mere tools in the description of child realizations in relation to adult targets (e.g. Grunwell, 1981; Stoel-Gammon and Dunn, 1985). Consequently, ordering constraints evident in child speech are considered either as a child's means of dealing with the task of acquisition or as a way of adequately describing the data.

The assumption of the psychological reality of PRs entails the hypothesis that the underlying form of a child realization is the adult phonemic form. This in turn implies that the child perceives

all the phonemic distinctions of normal adult speech. Grunwell (1981:59-61), however, argues that the evidence for the reality hypothesis (especially Smith, 1973) is not very convincing. She maintains that the demonstration of the ability of a child to discriminate minimal pairs is not an adequate measure of his overall perceptual ability (see also Ingram, 1976). Similarly (and again contrary to Smith's observation of his son A), children do not always appear to be aware of the difference between their own and the adult pronunciation, therefore suggesting that the underlying forms are not necessarily the adult phonemic forms. The psychological reality hypothesis further assumes that phonological changes occur 'across-the-board' so that new contrasts are never over-generalized (Smith, 1973). Again, it has been shown both in normal and disordered phonological development that variability occurs frequently and that this variability can involve over-generalization. (It must be noted, however, that in his 1978 paper Smith retracted some of his strong views on the psychological reality of phonological rules in child phonology.) On the basis of arguments such as these Grunwell (1981:61) concludes that

"It would therefore seem more appropriate to regard statements of correspondences between the child's pronunciation and the adult's merely as a descriptive account."

It would of course be highly desirable if rules or processes could be given some psychological status in that assessment and treatment programmes based on such analyses in the clinical context would have a more real and principled basis.

In line with the psychological reality of PRs hypothesis, Kiparsky and Menn (1977) argue for the reality of rule ordering as a strategy employed by a child in phonological acquisition. While Kiparsky and Menn argue against Stampe's rather deterministic conception of phonological acquisition as an 'unfolding of innate abilities', they agree with his view of ordering of processes as an essential part of acquisition. According to Kiparsky and Menn "... rule ordering is required in children's grammars at a rather early age". They quote the well-known phenomenon of displaced contrast as evidence for this assertion. The pronunciation of 'puzzle' as 'puddle' but 'puddle' as 'puggle' by Smith's (1973) son A is given as an example. In his speech the following two rules

Rule 1: $d \rightarrow g / ___1 \#$

Rule 2: $z \rightarrow d / ___1 \#$

had to apply in that order to produce the recorded realizations. In this case, the child is assumed to seek to represent as many adult contrasts as possible given his phonetic resources. In other words, in order to achieve this functional end the child uses a strategy which puts "...the rules in a non-feeding order" (Kiparsky and Menn, 1977:73) (non-feeding = counter feeding, see Section 4.1, above). As such, in child phonologies rules in a feeding order lead to a reduction in contrasts signalled while a non-feeding order preserves contrasts.

In their discussion on the learning of morphophonemics, Kiparsky and Menn also hypothesize that a child who has learned two rules without encountering evidence for their mutual ordering will set up a hypothesis that the rules apply in the unmarked feeding and bleeding orders. The following hypothetical example is given to illustrate this acquisitional strategy. Suppose that a child has mastered the rule determining the choice of plural suffixes in English:

i-insertion: $0 \rightarrow i / s, z, \int, _3, t^S, d_3 / ___z \#$

Suppose also that the child has the following rule:

t-deletion: $t \rightarrow 0 / ___ \left\{ \begin{array}{l} c \\ \# \end{array} \right.$

so that 'toast' becomes $[tə\omega s]$. It is predicted that a child with these rules who has never heard the plural form of a word like 'test' will pronounce it as $[tesɪz]$ even if forms like 'testing' has caused him to enter it in the lexicon with the underlying representation $/test/$. The reason is that the form $[tesɪz]$ results from the preferred unmarked feeding order:

Rule 1: t-deletion

Rule 2: i-insertion

A child may reorder these rules in light of encountering the correct adult form of 'tests'.

Derwing (1977) takes issue with Kiparsky and Menn's theory of phonological acquisition. According to Derwing, the rule ordering strategies discussed by Kiparsky and Menn are "...largely hypothetical 'linguistic' notions and not well established

psychological and physiological ones at all" (p.80). A child is considered a "little linguist" who "constructs grammars" by solving complex problems, while "...it is hardly obvious at all that the child ever sets out intentionally to learn a 'language system' at all, much less to go about his task with anything like the assiduousness, systematicity, or comprehensiveness of the linguist" (p.81). More specifically, Derwing argues that in the 'puzzle-puddle-puggle' example the surface realizations can be arrived at even if the rules applied in a random order. He maintains that a child who preserves the lexical contrast between 'puddle' and 'puzzle' evidently hears the difference between these two words, but cannot yet reproduce it accurately. Thus, the segment produced as [d] which corresponds to the target /z/ (i.e. 'puzzle' → 'puddle') is distinct for the child from the perceived segment [d] corresponding to /d/, otherwise "...why displace the contrast" (p.82).

viz. Rule A: $d \rightarrow g / ___ l \#$

Rule B: $z \rightarrow d / ___ l \#$

In other words the input of Rule A is distinct from the output of Rule B. If this was true, then it does not make sense to impose an ordering constraint, since a feeding relationship could not exist for the two rules by the very fact that the two /d/ segments are non-identical. The two rules do not interact.

Derwing's interpretation of the 'puzzle-puddle-puggle' example is as hypothetical as Kiparsky and Menn's. Yet, it conveniently illustrates how the same data can give rise to different interpretations. Therefore, as Derwing argues, linguistic theories based on observed language data are not psychological theories. These, he contends, should be based on "...controlled experiments" (p.84). It is of course yet another matter how one could investigate potential rule ordering strategies in child phonology in "a controlled experimental" fashion.

Salus and Salus (1974) also consider rule ordering in child phonology psychologically real. They take this consideration a step further by attempting to set up 'universally' (or at least cross-linguistically) valid ordering relationships amongst a set of phonological processes. They maintain that implicational hierarchies exist among processes so that the presence of one rule necessitates the presence of others and that given two rules they appear in a

given order. It is not difficult to see how problematic are the issues Salus and Salus attempt to discuss and this observation is indeed supported by their discussion. Firstly, the examples given in their paper are from only a few children, thus casting doubt on their assertion of the 'universality' of the process relationships. Secondly, it is clear that only some process relationships enter into implicational relationships with others. However, Salus and Salus give no evidence of having appreciated this. This is particularly apparent in the following example. Salus and Salus observed that the pronunciation patterns of Joan Velten were describable in terms of the following rules in the order specified:

(1) Cluster Simplification

$sp \rightarrow p / \# ___$

(2) Vowel Lengthening

$V \rightarrow \bar{V} / ___ \text{voiced obstruents}$

(3) Denasalization

$\text{Nasal} \rightarrow \text{Voiced Stop} / ___ \#$

(4) Devoicing

$\text{Voiced stop} \rightarrow \text{Voiceless Stop} / ___ \#$

While it is apparent that Vowel Lengthening must precede Devoicing and Denasalization can precede Devoicing, "...there is no good evidence that Vowel Lengthening and Denasalization are critically ordered regarding each other". Furthermore, Salus and Salus write that "though there is no conclusive evidence, we presume that Cluster Simplification preceded all these other processes" (p.35). The assumption that an order cannot be imposed on the respective processes because of lack of 'good' evidence is not strictly correct. It fails to appreciate that ordering constraints can only apply to rules with intersecting distributions (see Section 4.1, above). Cluster Simplification is in fact in complementary distribution with the other three processes and as such is not subject to ordering constraints in relation to the other processes. Furthermore, Vowel Lengthening and Denasalization are in fact ordered with respect to one another. Denasalization must apply before Vowel Lengthening in order for Vowel Lengthening not to be vacuous.

While Salus and Salus are apparently unaware of the

prerequisites for the presence of ordering constraints and of the various types of rule relationships recognized in the literature (namely, Kiparsky, 1968; Chafe, 1968), it is possible to show formally why the respective processes in the above example are in fact ordered.

(1) Vowel Lengthening (VL) > Devoicing (DE) (see above)

VL is in a counter feeding to Absolute Bleeding relationship with respect to DE. As such, VL must apply and can only apply, before DE (viz. The two rules are self-ordering).

(2) Denasalization (DEN) > Devoicing (DE) (see above)

DEN is in a feeding relationship with respect to DE. This relationship is determined in reference to data.

(3) Denasalization (DEN) > Vowel Lengthening (VL) (see above)

DEN is in a feeding relationship with respect to VL. This relationship is therefore determined in reference to data.

As is apparent from these formulations a rule (or a process) must precede another if

(i) there is only one possible ordering of the rules

(ii) the data requires two rules which are potentially interacting to apply in a certain order.

As was discussed in Section 4.1, the self-ordering relationships are not really ordering relationships proper in that such rules can apply only in the one order.

In addition to the above infelicities in Salus and Salus' discussion on rule ordering, their attempts at putting processes in some kind of consistent order are unlikely to result in meaningful insights about the nature of processes and their position in the description of child phonology. All one can apparently say in this regard is that certain processes appear to be self-ordering, but many processes can apply either randomly or in orders specifiable in relation to particular child data. There may of course be some common tendencies amongst children in preferring certain orders over others. There has not as yet been any discussion of this issue in the literature on child phonology.

As has been established in this chapter thus far, there are instances where no apparent order of rule application is needed.

This is the case when two rules are in non-intersecting distribution, are self-ordering or totally non-interacting. A further kind of situation seems to have been recognized in the literature (Grunwell, 1982). In this case, the rules have intersecting distributions and are non-self-ordering and yet no ordering constraints are necessary. The following example illustrates this (Grunwell, 1982:152):

Rule 1: $s \rightarrow 0 / \# ___ C$ $skɪpɪŋ \rightarrow kɪpɪŋ$

Rule 2: $\text{velar} \rightarrow \text{alveolar} / \# ___$ $tɪpɪŋ$

Rule 3: $\text{voiceless} \rightarrow \text{voiced} / \# ___$ $dɪpɪŋ$

Grunwell writes that "...there are apparently no reasons for imposing an order upon the application of these rules" (p.152). It is indeed true that any sequential combination of these three rules produces the same outcome (i.e. $[dɪpɪŋ]$) since the rules are stated as general rules which consist of more specific rules viz.

Rule 1: $st \rightarrow t / \# ___ C$	Rule 2: $k \rightarrow t / \# ___$	Rule 3: $t \rightarrow d / \# ___$
$sk \rightarrow k / \# ___ C$	$g \rightarrow d / \# ___$	$k \rightarrow g / \# ___$
$sp \rightarrow p / \# ___ C$	$ŋ \rightarrow n / \# ___$	$p \rightarrow b / \# ___$
etc.		etc.

Here are two examples of how different orders of the three rules can produce the same outcome:

Example 1:

Rule 2: $kɪpɪŋ$

Rule 3: $tɪpɪŋ$

Rule 1: $dɪpɪŋ$

Example 2:

Rule 3: $sgɪpɪŋ$

Rule 2: $sdɪpɪŋ$

Rule 1: $dɪpɪŋ$

The question is whether all the possible ordering relationships are likely ones. The answer to this question hinges upon the motivations behind rule ordering in child phonology. In the description of the correspondences between targets and child realizations, rules may need to be ordered to reflect the actual child realizations. While all the orderings of the above rules indeed produce the actual child realization, only one of them is likely to be an appropriate one reflecting the overall patterns in that child's speech. In other words, the rules or processes in the derivation of the output should not be determined arbitrarily, but in relation to the operation of the rules or processes in a whole set of an individual child's speech patterns. In this way, the derivations reflect the state of the child's phonological system more accurately. This kind of

analysis of child data is also necessary for the assessment of the functional adequacy of the phonological system (see Section 4.3) and for devising of possible treatment goals on the basis of such an assessment (see Chapter 6). Therefore, in regard to Grunwell's example, one would need to consider whether the child's speech exhibited patterns such as /sk→k/, /k→g/ and /g→d/ reflecting the derivational stages in Example 1, patterns such as /sk→sg/, /sg→sd/ and /sd→d/ reflecting the derivational stages in Example 2 or perhaps some other patterns.

The role of rule ordering in the study of child phonology has been overviewed in this section. While it has been recognized that it is yet to be shown whether rule ordering could be considered an acquisitional strategy employed by the child, it is maintained that correspondences between adult targets and child realizations can be described in terms of rules or processes and sometimes these rules or processes need to be ordered to reflect both particular child realizations and their speech patterns in general. It however remains to be shown the extent to which rule ordering is actually required for such descriptions. It is also suggested that ordering of rules may bear some relevance in the assessment of phonological systems and that as such it is a concept which is pertinent to the assessment of the functional adequacy of restricted phonological systems. The next section examines the role of rule ordering in such assessment.

Section 4.3: Ordering of Phonological Processes in the Assessment of the Functional Adequacy of Children's Phonological Systems

The phonological processes studied in the present investigation (see Chapter 5, Section 5.2.1 and Appendix 3) are 'abstract' reflections of the phonological processes that have been found to operate in children's speech. As such ordering constraints cannot be imposed upon them to reflect children's speech patterns. The processes in this study describe correspondences between a child lexical system supported by a complete phonological system (i.e. adult phonemic system) and a child lexical system supported by an incomplete phonological system. The description of child phonology, on the other hand, generally reflects the correspondence between

adult targets and actual child realizations. It is this difference in the role of processes which does not permit the present investigation to impose data-based ordering constraints on the processes studied. It can, however, be argued that despite this difference, the kinds of ordering constraints which will be imposed on the processes in this study to reflect differing functional consequences of the different orderings will bear some relevance to the ordering constraints which may have to be postulated to account for the patterns in actual data. After all, the targets which will be hypothesized and real child realizations are potentially the same. As such, the issues concerning rule ordering discussed in this section are potentially applicable to the analysis of actual child data (see Chapter 6).

4.3.1 Combinations of Phonological Processes Operating in the Same Place in Syllable Structure

4.3.1.1 Feeding and Bleeding Relationships

It is not appropriate in the present study to maintain that, for instance, Fronting of /k/ to [t] and Prevocalic Voicing of /t/ to [d] must apply in a feeding order. In real data they could equally well enter a counter feeding relationship. As such, the two relationships are not really ordering relationships as ordering is generally defined. The point is however, that the above two relationships have a potentially different effect on the functional adequacy of the phonological system in terms of FLOSS and multiple homophony. On this basis, the two processes (see Chapter 3 for how the term 'process' is used in this study) can be considered ordered with respect to one another. For instance, two processes in a feeding order (cf. Complete vs. Incomplete Feeding, below) are potentially compatible with new homophony while two processes in a counter feeding order are incompatible with new homophony. That is to say that the presence of a feeding order potentially produces instances of homophony (=homophonous pairs) which would not be produced if the two processes did not enter a feeding relationship. This can be illustrated by the following example:

Fronting k-t and Prevocalic Voicing t-d in a feeding relationship (WI-position)

Lexical Sample (complete ph. system)		Lexical Sample (incomplete ph. system)	
/kɪp/	tɪp	/dɪp/	*
/kɪk/	tɪk	/dɪk/	*
/tɪp/		/dɪp/	
/tɪk/		/dɪk/	
/dɪp/		/dɪp/	
/dɪk/		/dɪk/	

The new instances of homophony produced by the feeding interaction are marked by an asterisk. Whether the potential for new homophony is realized by the two processes in a feeding order depends upon the actual lexical sample.

A counter feeding relationship, on the other hand, is incompatible with new homophony in that no instances of new homophony are produced as a result of the two processes entering a combination. In fact, the homophony produced equals the homophony induced by the process which is ordered first in the counter feeding relationship. In other words, the potential for homophony production by the second process is lost. This is illustrated in the example below:

Prevocalic Voicing t-d and Fronting k-t in a Counter-feeding Relationship (WI-position)

Lexical Sample (complete ph. system)		Lexical Sample (incomplete ph. system)	
/tɪp/		/dɪp/	
/tɪk/		/dɪk/	
/dɪp/		/dɪp/	
/dɪk/		/dɪk/	
/kɪp/		/tɪp/	} no matching forms
/kɪk/		/tɪk/	

As this example shows, the Fronting process cannot produce any homophony since all the forms in the lexical sample which the resultant forms (i.e. /tɪp/ and /tɪk/) could have potentially matched with have undergone the Prevocalic Voicing process, thus preventing any potential homophony.

Of the two bleeding relationships (viz. bleeding and counter

bleeding), Segmental Bleeding relationships are incompatible with new homophony, while counter bleeding to Absolute Contextual Bleeding is potentially compatible with new homophony. Since there does not appear to be any instances of Contextual Bleeding or counter bleeding to Contextual Bleeding in the literature on the phonological processes examined in this study, these two relationships will not be examined further. The incompatibility with new homophony of a Segmental Bleeding relationship hinges upon the 'subtractive' nature of the relationship. In the following Segmental Bleeding relationship

Process A: $s \rightarrow f$ /#___w

Process B: $s \rightarrow \emptyset$ /#___C

Process A produces the same homophony as if it operated on its own (i.e. not in a combination with the other process). Process B, on the other hand, produces potentially less homophony than it would produce on its own since the opportunity for homophony production via words such as /swip/ $\rightarrow$ /wip/ or /swei/ $\rightarrow$ /wei/ is removed by the presence of Process A. Thus, this ordering relationship is incompatible with new homophony.

The potential compatibility with new homophony of the counter bleeding to Absolute Contextual Bleeding, on the other hand, depends on the two processes operating in a different place in a word. This can be illustrated by the well-known example of the combination of Velar Harmony and Final Consonant Deletion in child phonology:

Velar Harmony: $d \rightarrow g$ /___Vg#

F.C.D.: $g \rightarrow \emptyset$ /___#

The word 'dig' in a lexical sample becomes /gɪ/ by the operation of the two processes. If, then, the word 'gig' was part of the lexical sample, a new homophonous pair would be produced (i.e. /dɪg/ $\rightarrow$ /gɪ/ and /gɪg/ $\rightarrow$ /gɪ/).

It has been thus far established that ordering relationships existing between combinations of two processes can enter into predictable relationships with regard to the resultant homophony. Only those process relationships will be considered further which can hold between combinations of the eight processes subjected to the analysis of FLOSS and IMH in the present study (see Section 5.2.1 and Appendix 3). Furthermore, Bleeding relationships cannot be

established in the present study since only combinations of two processes are considered and since all the processes studied are stated in such specific terms (e.g. $s \rightarrow 0 / \# _k$ rather than $s \rightarrow 0 / \# _C$) that one process cannot restrict the operation of another process. Similarly, because of the nature of the processes selected for this study (i.e. no context-sensitive processes; see Section 5.2.1), there are no Contextual Bleeding or counter bleeding relationships. Therefore, of the ordering relationships discussed in the preceding sections only feeding and counter feeding relationships can be operative amongst the processes studied and these will be considered further below.

4.3.1.2 Feeding Relationships in the Present Study

4.3.1.2.1 Complete Feeding

The feeding relationships can be divided into two types of feeding relationships which can be shown to hold between the processes studied and while both types are potentially compatible with new homophony, they appear to have potential for different functional consequences. One of these feeding relationships, namely Complete Feeding, is considered in this section. A Complete Feeding relationship holds if

all outputs of Process 1 serve as an input to Process 2

Process 1: $a \rightarrow b$

Process 2: $b \rightarrow c$

In the present study, Process 1 is either a Word Initial Cluster Reduction process or one of the context-independent processes, while Process 2 must be a context-independent process (see the feeding example in the above section).

While Complete Feeding is potentially compatible with new homophony by virtue of the feeding interaction, actual occurrence of new homophony does not necessarily entail that more homophony is produced in relation to an additive FLOSS-value for the two processes operating individually (An additive FLOSS-value is the sum of the FLOSS-values for the two processes when they operate as single processes on a lexical sample; see Section 5.3, below). This hinges upon the fact that the homophony produced by the first process when it operates as a single process cannot be produced when this process enters into a feeding relationship. For instance, if

the following two processes entered a feeding interaction

Process 1: $k \rightarrow t$

Process 2: $t \rightarrow d$

Process 1 could not produce any homophony in the lexical system as a function of the contrast /k,t/ missing from the phonological system since the actual contrast that is missing is /k,d/. It is thus apparent that additive FLOSS-values do not really exist for Complete Feeding relationships and therefore the occurrence of new homophony does not necessarily entail that the combination of two processes in a Complete Feeding relationship is more detrimental to the functional adequacy of the phonological system than if the two processes operated singly. It depends on the contrasts which are lost from the phonological system and the actual lexical system which the phonological system supports whether more or less homophony is produced by the combination of the two processes than by the individual processes.

The second process in a Complete Feeding relationship does not necessarily produce all the homophony in such a combination as it would produce when operating individually. Some homophony may be lost due to the process specification of the second process becoming altered as a function of the process entering a combination. The term 'process specification' refers to the range of structures in which the process operates. For instance, the combination of the Cluster Reduction of 'tr-t' and the Prevocalic Voicing of 't-d' in a Complete Feeding relationship (WI-position) would entail an alteration of the process specification of the Voicing process (i.e. Process 2) to exclude the operation of the process in /tr/-clusters. Therefore, homophones such as /trein/ vs. /drein/ which would occur if the Voicing process operated individually would disappear when the process enters the particular combination. Therefore, a Complete Feeding relationship with an altered process specification has the potential to produce less homophony than a Complete Feeding relationship with an unaltered process specification. It must be noted, however, that this is only true of those altered process specifications which have potential for homophony. For instance, an altered process specification 'tr-vr' resulting from the combination of the processes 'fr-f' and 'f-v' in a Complete Feeding relationship has the same potential for homophony as Complete Feeding

relationships with unaltered process specifications. This is because the operation of the Voicing process on the cluster /tr/ would not produce any homophony when it operates on its own.

The alteration of process specifications in Complete Feeding relationships thus has the potential effect of producing 'less' homophony than produced by the second process. For this to happen the first process would need not to produce any homophony via the feeding interaction. In other words, the relationship would need to be actually incompatible with new homophony. The chances for this happening in the analysis of actual lexical systems may be fairly limited. This potential for producing less homophony is not however present if the process specification is not altered. Therefore, it is possible to maintain that Complete Feeding relationships with unaltered process specifications are potentially, however very slightly, more destructive for the functional adequacy of the phonological system than Complete Feeding relationships with an altered process specification.

It must be noted that the potential for the alteration of process specifications in the present study depends on the assumption that context-independent processes can operate in clusters. There is some indication in the literature on child phonology that context-independent processes are indeed sometimes operative in clusters (e.g. Grunwell, 1982; Edwards and Shriberg, 1983).

The counter feeding to Complete Feeding relationship is incompatible with new homophony (see Section 4.3.1.1). This is so for combinations of processes with both altered and unaltered process specifications. As was pointed out above the incompatibility with new homophony hinges upon the fact that there is no interaction between processes in a counter feeding relationship. Furthermore, the homophony produced by two processes in a counter feeding to Complete Feeding relationship with unaltered process specifications equals the homophony produced for the second process when it operates as a single process (see the above example). The homophony produced by two processes in a counter feeding to Complete Feeding relationship with an altered process specification either equals the homophony produced by Process 2 (the altered process specification has no potential for homophony)

e.g. Process 2: f-v (ex. fr-vr)

Process 1: fr-f

('ex. fr-vr' indicates that the process specification of Process 2 is altered to exclude the operation of the process in /fr/ clusters)

or is potentially less than the homophony produced by Process 2 (the altered process specification has potential for homophony)

e.g. Process 2: t-d (ex. tr-dr)

Process 1: tr-t

4.3.1.2.2 Incomplete Feeding

The second type of feeding relationship which can hold between the processes studied is an Incomplete Feeding relationship. This can be defined as follows:

An Incomplete Feeding relationship exists when only some instances of the output of the first process serve as an input for the second process.

e.g. Process 1: $a \rightarrow b$

$ax \rightarrow bx$

Process 2: $bx \rightarrow b$

Incomplete Feeding relationships depend on two assumptions (see also altered process specification, above).

(1) Context-independent processes can operate in clusters

e.g. Process 1: $g \rightarrow d$ (Prevocalic Voicing)

$gr \rightarrow dr$

Process 2: $dr \rightarrow d$

(2) Two term cluster reduction patterns also operate in three term clusters

e.g. Process 1: $st \rightarrow t$ (WI Cluster Reduction)

$str \rightarrow tr$

Process 2: $tr \rightarrow t$

There is some indication in the literature that context-independent processes can in fact operate in clusters in child phonology (e.g. Grunwell, 1982; Edwards and Shriberg, 1983) and there is also evidence of patterns of the second type in child phonology (e.g.

Grunwell; 1981). Beyond the initial reduction patterns of three term clusters to single consonants, the further development of these cluster patterns may involve emergence of two term cluster patterns in place of three term ones.

As with Complete Feeding relationships, process specifications of processes entering an Incomplete Feeding relationship can be either unaltered or altered, and the former has potential for more homophony than the latter (see below). As the following example of an Incomplete Feeding relationship with an unaltered process specification shows, the outputs of the two processes can be (but do not necessarily have to be; see below) identical:

The two processes can be said to conspire to the same segment (see also Section 4.3.1.3 below). As such this type of Incomplete Feeding relationship bears potential for new homophony via both the feeding interaction and the conspiring relationship. In reference to the two above processes this can be illustrated with the following example:

Lexical Sample (complete phonological system)	Lexical Sample (incomplete phonological system)
/fain/_____	/pain/_____
/pain/_____	/pain/_____
/feis/_____	/peis/_____
/peis/_____	/peis/_____
/pleis/_____	/peis/_____
/fæn/_____	/pæn/_____
/pæn/_____	/pæn/_____
/flæn/_____	plæn _____
/plæn/_____	/pæn/_____
/flai/_____	plai _____
/plai/_____	/pai/_____
/pai/_____	/pai/_____
/plein/_____	/pein/_____
/pein/	/pein/

The sections numbered 1 and 5 show the presence of no new homophony. That is to say that the homophonous forms (pairs) result from no interaction between the two processes. Section 2, on the other hand, indicates interaction via conspiracy in form of new homophonous pairs. If the two processes had operated singly on the lexical system,

/feis/→ /peis/	/pleis/→ /peis/
/peis/→ /peis/	/peis/→ /peis/

then one homophonous pair per each process would have been produced. While both sections 3 and 4 show interaction via Incomplete Feeding, section 3 illustrates a co-occurrent conspiring relationship. This in turn increases the potential for more new homophonous pairs. It must be further noted that new homophony can also be produced solely by the presence of a conspiring relationship (see further Section 4.3.1.3).

A Counter Feeding to Incomplete Feeding relationship with an unaltered process specification is still potentially compatible with new homophony. This potential compatibility hinges upon the conspiring relationship which remains.

e.g. Process 2: pl→ p
 Process 1: f→ p
 fl→ pl

This counter feeding relationship has however less potential for new homophony (=potentially a less detrimental effect on the functional adequacy of the phonological system) than the corresponding Incomplete Feeding relationship. This is apparent from the fact that the maximum number of identical homophonous forms for an Incomplete Feeding relationship with an unaltered process specification is four which results from the co-occurrence of Incomplete Feeding and Conspiring, while for the corresponding counter feeding relationship it is three, resulting from the Conspiring relationship.

e.g. Incomplete Feeding	Counter Feeding to Incomplete Feeding
fæn → pæn	fæn → pæn
flæn → pæn	flæn → plæn
plæn → pæn	plæn → pæn
pæn → pæn	pæn → pæn

Five types of Incomplete Feeding relationships with an altered process specification can be established on the basis of the processes studied. While all the types of relationships exhibit an Incomplete Feeding relationship they are not all potentially compatible with new homophony. Furthermore, there are some differences in their effect on the functional adequacy amongst the different types of relationships. However, as will become apparent in the discussion in Chapter 6, the potential differences demonstrable theoretically may be only marginal in an actual analysis of data. Furthermore, in regard to altered process specifications the presence of new homophony does not necessarily entail that more homophony than is reflected in the corresponding additive value for the two processes is produced. These generalizations will become apparent below.

Contrary to the Complete Feeding relationships with altered process specifications it is evident that for Incomplete Feeding relationships with altered process specifications either process can be altered. This difference results from the difference in the nature of the feeding relationship. For a Complete Feeding relationship, an altered process specification only occurs when the processes operate in one specific order. With an Incomplete Feeding relationship, an altered process specification may occur when the two processes operate in either order, with the proviso, that the process specifications of different processes are altered.

e.g. Process 1: st - t

str - tr

Process 2: tr - t (ex. str - st)

- The process specification of Process 2 is altered to exclude 'str - st'.

e.g. Process 1: tr - t

str - st

Process 2: st - t (ex. str - tr)

- The process specification of Process 1 is altered to exclude 'str - tr'

As will be seen shortly, there is some variation amongst the five types of Incomplete Feeding relationships in this regard. The point

is however, that the homophonous forms produced for the two orderings of the same processes in an Incomplete Feeding relationship are potentially different by virtue of the alteration of different process specifications. Therefore, the functional adequacy of phonological systems potentially differ. It is however not always possible to predict the direction (i.e. in terms of more or less homophony than the corresponding additive value) of the potential difference, since this is dependent on the actual lexical sample. Yet, as will be seen shortly, such predictions are sometimes possible. When Process 1 is unaltered and Process 2 altered, this will be referred to as Condition A and when Process 1 is altered and Process 2 unaltered this will be called Condition B.

e.g. Condition A:

e.g. Condition B:

The first type of Incomplete Feeding relationship with an altered process specification will be referred to as Type1IF. Type1IF is characterized by both an incomplete feeding interaction and a conspiring interaction. Furthermore, the altered process specifications have potentially an effect on the homophony produced in comparison to the homophony which could have been produced by the process with an altered process specification if it was not altered. This in turn means that the presence of new homophony does not necessarily mean that more homophony is produced by the two processes in a combination as compared to the additive FLOSS-value

for the single processes. It would however seem somewhat unlikely that the alteration of process specifications would have any considerable effect on the homophony produced (see Chapter 5, Section 5.4 and Chapter 6). The above examples for Conditions A and B illustrates Type1IF relationships. As is apparent from these examples, the maximum number of identical homophonous forms that Type1IF relationships can produce is four (both Condition A and B).

e.g. /stei/ → /tei/
 /strei/ → trei → /tei/
 /trei/ → /tei/
 /tei/ → /tei/

This in turn indicates the potential of processes in a Type1IF relationship for greater functional loss, as measured in terms of homophonous pairs and multiple homophony, than processes in a Complete Feeding relationship. This is also true of the Incomplete Feeding relationships with unaltered process specifications in comparison to Complete Feeding relationships.

A counter-feeding to Type1IF (Condition A and B) remains potentially compatible with new homophony owing to the conspiring relationship.

e.g. Condition A:

Process 2: tr - t (ex.str - st)
 Process 1: st - t
 str - tr

Condition B:

Process 1: st - t (ex. str - tr)
 Process 2: tr - t
 str - st

The counter feeding relationships have potential for producing less homophony than the sum of the corresponding individual FLOSS-values (i.e. additive FLOSS-values) by virtue of the altered process specifications. Furthermore, the Type1IF relationships have potential for more homophony than the respective counter feeding relationships. This results from the former including both a feeding and a conspiring relationship while the latter consists of only a

conspiring relationship.

The second type of Incomplete Feeding relationship identified on the basis of the processes studied will be referred to as Type2IF. While Type2IF shares several characteristics with Type1IF, it also differs from Type1IF in number of regards. As the Type1IF relationship, Type2IF also consists of a conspiring relationship in addition to an Incomplete Feeding relationship. The major difference is however, that the output of the feeding interaction in Type2IF relationships is a non-English segment sequence, while this output for Type1IF consists of a permissible English segment sequence (see the example above for Type1IF). A further difference is that the characteristics of Type2IF Condition A and Condition B are not identical (see further below) while they are identical for Type1IF. A Type2IF (Condition A) relationship can be illustrated by the following example:

e.g. Condition A:

```
Process 1: tr - t
           str - st
                ↓
Process 2: s - t
           st - tt (ex. str - ttr)
```

The consequence of the non-English output of this type of Incomplete Feeding relationship is that the feeding relationship has the potential of producing only the maximum number of two identical homophonous forms.

e.g. /streɪ/ → steɪ → /tteɪ/
 /stɛɪ/ → /tteɪ/

There are no words of the form /tteɪ/ in a lexical sample consisting of English words to match up with the resultant forms produced by the feeding interaction. The maximum number of identical homophonous forms produced by the conspiring relationship part of the Type2IF relationship, however, is three (see Section 4.3.1.3). This then indicates that while the feeding interaction has no potential for multiple homophony, multiple homophony can be produced by processes in a Type2IF relationship via the conspiring relationship. The '/streɪ/ - /tteɪ/' example also illustrates how the

Incomplete Feeding relationship can not either produce any new homophony in comparison to the homophony that would be produced by the first process if it operated as a single process. In other words, if Process 1 (i.e. tr - t; str - st) operated without entering the Incomplete Feeding relationship, the same amount of homophony would be produced than if it entered such a relationship.

e.g. /strei/ → /stei/
 /stei/ → /stei/

The actual form of the homophonous forms would however differ, and therefore there may be some motivation in child phonology for processes to enter into Type2IF relationships. But, from the point of view of the extent of resultant homophony, Type2IF (Condition A) is potentially compatible with new homophony only because of the conspiring relationship. Because of this, Type2IF relationships have potential for less homophony and multiple homophony than Type1IF relationships.

It must be noted at this point that while high FLOSS values can indicate the presence of multiple homophony (i.e. high IMH) this is not necessarily always the case. New instances of homophony can be indicative of two homophonous types being represented by one homophonous form.

e.g. /si/ → /ti/ The lexical item 'tea' assumed not
 /ki/ → /ti/ part of the lexical system.
 /sein/ → /tein/
 /kein/ → /tein/

As is apparent from the example of Type2IF (Condition A) relationship above, the altered process specification (e.g. str - ttr, in the example) in this type of relationship does not have any potential effect on homophony. In other words, the altered process specification does not have any potential for loss of homophone pairs since there cannot be any minimal pairs distinguished by WI-clusters /str - ttr/. Furthermore, in the counter feeding to Type2IF (Condition A) relationships the apparent Incomplete Feeding interaction disappears. The two processes are still potentially compatible with new homophony because of the remaining conspiring relationship.

e.g. Process 2: s - t (ex. str - ttr)

Process 1: tr - t

str - st

Since the altered process specification does not have any effect on homophony, the potential for lower FLOSS by virtue of altered process specifications is not realized. Furthermore, Type2IF (Condition A) relationships do not have potential for higher FLOSS than the corresponding counter feeding relationships, because of the Incomplete Feeding interaction being incompatible with new homophony.

Type2IF (Condition B) is identical to Type2IF (Condition A) in that the Incomplete Feeding interaction has no potential for producing new homophony, while the relationship is potentially compatible with new homophony owing to the Conspiring relationship.

e.g. Condition B:

Process 2: s - t

str - ttr

Process 1: tr - t

ttr - tt (ex. str - st)

It is apparent that no homophony can be produced by the feeding interaction since there are no words in an English lexical sample with the word initial segment clusters /ttr/ and /tt/

e.g. /strei/ → ttrei → /ttei/

As such, Type2IF (Condition B) relationships are essentially Conspiring relationships with altered process specifications. However, contrary to Type2IF (Condition A) relationships the process specification for Type2IF (Condition B) has the potential for loss of homophone pairs in comparison to the homophone pairs produced by the respective individual processes. For instance, in the above example for Type2IF (Condition B) homophone pairs such as /stro/ vs. /stɔ/ and /strei/ vs. /stei/ could be lost owing to the alteration of the process specification. Therefore, the production of new homophony does not necessarily entail that more homophony is produced in comparison to the additive FLOSS-value. Furthermore,

since Type2IF (Condition B) is essentially a Conspiring relationship, the corresponding counter feeding relationships are also Conspiring relationships and as such has the same potential for homophony as the corresponding non-counter feeding relationships.

e.g. Process 1: tr - t (ex. str - st)

Process 2: s - t

str - ttr

Owing to the nature of the altered process specification, a counter feeding to Type2IF (Condition B) relationship has potential for lower FLOSS-value than the corresponding additive value.

The third type of Incomplete Feeding relationship, Type3IF, differs from the two previous ones in that the only interaction of the two processes is via Incomplete Feeding.

e.g. Type3IF (Condition A)

Process 1: sk - k

skr - kr

Process 2: r - j

↓
kr - kj (ex. skr - skj)

Type3IF has potential for less homophony than the additive FLOSS-values for the respective single processes owing to the altered process specification. Furthermore, the maximum number of identical homophonous forms is four.

e.g. /skru/ → kru → /kju/ ; Incomplete Feeding operates

/kru/ → /kju/ ; Process 2 operates

/skju/ → /kju/ ; Process 1 operates

/kju/ → /kju/ ; A word beginning with a /kj/
cluster in the lexical sample

Therefore, Type3IF (Condition A) has more potential for multiple homophony than Type1IF (Condition A and B) and Type2IF (Condition A and B). This is likely not to be the case in actual analysis of lexical samples, since it is very difficult to think of many

examples of Type3IF combinations in which the maximum number of identical homophonous forms are produced. Type3IF (Condition A) has, on the other hand, less potential for FLOSS (homophone pairs) than the other two types of Incomplete Feeding relationships with altered process specifications, since it is characterized only by an Incomplete Feeding relationship while the others are characterized by Incomplete Feeding and Conspiring relationships.

A counter feeding to Type3IF (Condition A) relationship is a totally non-interactive relationship, and as such is incompatible with new homophony.

e.g. Process 2: r - j (ex. skr - skj)

Process 1: sk - k

skr - kr

It has, however, potential for less homophony than the respective additive FLOSS-value for the two individual processes owing to the altered process specification. Because of being incompatible with new homophony, the counter feeding relationship has potential for less homophony than the corresponding Type3IF (Condition A) relationship. It is doubtful, however, whether much new homophony can be produced by Type3IF (Condition A) relationships in actual lexical samples and thus whether this potential difference can be realized.

Type3IF (Condition B) behaves in an identical manner to Type3IF (Condition A). The only difference between the two is, however, in the potential for different, but unpredictable, functional consequences owing to the alteration of different process specifications.

e.g. Type3IF (Condition B)

Process 1: r - j

skr - skj

Process 2: sk - k

skj - kj (ex. skr - kr)

A comparison of this example with the example for Type3IF (Condition A) indicates the existence of a potential difference in the actual homophonous pairs being lost because of the different altered process specifications. In regard to real data, this difference is most likely very marginal (see Chapter 6). In fact, it is difficult to think of many minimal pairs in the English language

differentiated by /skr/ vs. /kr/ or /skj/ vs. /kj/.

The outcome of the Incomplete Feeding Interaction in Type3IF relationships is an English segment sequence. The fourth type of Incomplete Feeding relationship, Type4IF, is similar to Type3IF relationships in that the only interaction is through Incomplete Feeding. The difference is, however, that the output of the feeding interaction is a non-English segment sequence. Furthermore, Type4IF relationships can be divided into two subtypes on the basis of a difference in the nature of altered process specifications (Type4IF(i) and Type4IF(ii)). The difference between these two subtypes will become apparent shortly and is operative only in Condition A.

Type4IF(i) is potentially compatible with new homophony. However, new homophony does not mean that more homophony than the corresponding additive FLOSS-value is produced. This is because of the nature of the feeding interaction (the outcome is a non-English segment sequence; see also Type2IF, above). The FLOSS-value is either additive or less than additive because of the altered process specification.

e.g. Type4IF(i)

Process 1: r - w

skr - skw

Process 2: k - t

skw - stw (ex. skr - str)

As with Type2IF relationships, no multiple homophony can be produced because of the nature of the feeding interaction (i.e. the maximum number of identical homophonous forms is two). It is however, very difficult to think of many minimal pairs which are differentiated by the word initial cluster /skr/ and /skw/ (e.g. /skriz/ vs. /skwiz/) and therefore the production of any new homophony by this relationship may be marginal. Because of the nature of Type4IF (i) relationships, they have less potential for FLOSS and multiple homophony than the other three Incomplete Feeding relationships examined thus far. Furthermore, Type4IF(i) has potential for less homophony than the corresponding additive FLOSS-value because of the altered process specification (i.e. homophony may be lost because of the altered process specification e.g. /skrim/ vs. /strim/).

A counter feeding to Type4IF(i) relationship is a non-interactive relationship and as such incompatible with new homophony. Because of the altered process specification the counter feeding relationship has also potential for less homophony than the respective additive FLOSS-value.

e.g. Process 2: k - t (ex. skr - str)

Process 1: r -w

skr - skw

Type4IF(i) (Condition B) behaves in an identical manner to Type4IF(i) (Condition A). However, there is a difference which in fact is totally dependent on the actual lexical sample, and therefore, not predictable. This difference is reflected both in the feeding interaction and the altered process specification.

e.g. Type4IF (i) (Condition B)

e.g. Process 2: k - t

skr - str

Process 1: r - w ↓
 str - stw

The potential difference becomes more apparent in the following comparison:

Type4IF(i) (Condition A): skr → skw → stw

Type4IF(i) (Condition B): skr → str → stw

Occurrence of homophony for Condition A depends on the presence of the appropriate words with a /skw/-cluster in the WI position in the lexical sample, while it depends on the presence of /str/-words for Condition B. Furthermore, the alteration of different process specifications give rise to potentially different, however again unpredictable, functional consequences. In actual assessment of functional adequacy of phonological systems on the basis of lexical samples (in particular in reference to children's lexical systems) these differences seem negligible (see Chapter 6).

Type4IF(ii) (Condition A) is otherwise identical with Type4IF(i) (Condition A) except for the altered process specification. In Type4IF(ii) (Condition A) the altered process specification has no potential effect on FLOSS. As with Type4IF(i)

(Conditions A and B), Type4IF(ii) (Condition A) can produce new instances of homophony, but not more homophony than is produced by the individual processes (i.e. additive FLOSS-value). This is due to the outcome of the feeding interaction which is a non-English segment sequence (see also Tpe2IF above). Therefore, while there is potential for Type4IF(i) relationships to produce less homophony than the corresponding additive FLOSS-value owing to the nature of the altered process specifications, there is no such potential for Type4IF(ii) (Condition A) relationships. The FLOSS is simply additive from the individual FLOSS values.

e.g. Type4IF(ii) (Condition A)

```

Process 1: sp - p
           spr - pr
Process 2: r - w   ↓
                pr - pw (ex. spr - spw)

```

It is now apparent that the FLOSS for the corresponding counter feeding relationship is potentially less than the additive value:

```

e.g. Process 2: r - w
           pr - pw
Process 1: sp - p
           spr - pr

```

The potential for less homophony than the additive FLOSS-value can be further illustrated as follows:

e.g.- non-counter feeding:

```

/sprei/ → prei → /pwei/
/prei/ → → → /pwei/

```

- counter feeding

```

/prei/ → /pwei/
/sprei/ → /prei/

```

Because of the nature of the process specification in Type4IF(ii) (Condition A) (i.e. no potential for homophony reduction), Type4IF(ii) (Condition B) is incompatible with new homophony. This has the consequence that the apparent feeding interaction cannot produce any instances of new homophony (cf. Type2IF (Condition B)).

e.g. Type4IF(ii) (Condition B) (WI position)

Process 2: r - w

spr - spw

Process 1: sp - p

spw - pw (ex. spr - pr)

The nature of the altered process specification in Condition B does however bear potential for less than the additive FLOSS-value for the two processes. For instance, potential homophones such as /sprei/ vs. /prei/ can be lost when the process specification of Process 2 is altered. A counter feeding to Type4(ii) (Condition B) is also a non-interacting relationship, with the same potential for homophony as the corresponding non-counter feeding relationship. That is to say that the FLOSS-value equals either the additive FLOSS-value or less than this value owing to the altered process specification.

e.g. Counter feeding to Type4(ii) (Condition B) (WI position)

Process 1: sp - p (ex. spr - pr)

Process 2: r - w

spr - spw

These Incomplete Feeding relationships have been established on the basis of the processes examined in the present study. It has also been observed that Type3IF and Type4IF relationships can operate simultaneously. That is to say, that two processes may enter into two types of Incomplete Feeding relationships because of their ability to operate both on two-term and three-term clusters. Such instances of Incomplete Feeding shall be referred to Type3+4IF relationships.

e.g. Type 3+4IF (WI position)

Process 1: l - j

pl - pj

spl - spj

Process 2: p - b

and

pj - bj

spj - sbj

The operation of Process 1 and 2 on the two-term clusters can be viewed as Type3IF in that the only interaction between the two

processes is via Incomplete Feeding and that such interaction has potential for producing new homophony. Furthermore, the altered process specification has potential for loss of homophony in comparison to the additive value (e.g. Process 2: process specification altered to exclude 'pl - bl'). However, there is a difference from the Type3IF relationship in that the maximum number of identical homophonous forms is three as a result of Type3IF relationship in the above example, while this number is four when Type3IF operates on its own. It seems however, that the above relationship shares enough characteristics with Type3IF relationship 'proper' to justify it as a Type3IF relationship. Type4IF relationship in the combined interaction reflects the Type4IF relationships examined above. In this example, the two processes enter a Type4IF(ii) relationship, which is apparent from the fact that the Incomplete Feeding relationship has no potential for producing more homophony than the additive FLOSS-value and that the altered process specification has no effect on homophony (e.g. spl - sbl). Type3+4IF relationships can be considered potentially more detrimental for the functional adequacy of a phonological system than the other Incomplete Feeding interactions in that there are two such interactions present while there is only one in the other relationships. It can be argued that the presence of two Incomplete Feeding relationships provides more opportunity for the production of new homophony than the presence of one such relationship.

All the examples for Incomplete Feeding have involved the operation of the processes in the WI position. The relationships can however be evident also in WF positions (see Section 5.4 for the relationships established in the WF position). Another type of Incomplete Feeding relationship can however be established for processes operating in the WF position when they operate on inflected word endings. These type of relationships will be referred to as Type5IF relationships. The only interaction between the two processes is via Incomplete Feeding.

e.g. Type5IF (Condition A) (WF position)

Process 1: d - t

dz - tz

Process 2: z - s

tz - ts (ex. dz - ds)

Owing to the non-English nature of the interacting segment sequence (i.e. tz), the maximum number of identical homophonous forms is two.

e.g. /raidz/ - raitz - /raits/; Type5IF (Condition A) interaction
 /raits/ —————> /raits/; A lexical item present in the sample.

Furthermore, the altered process specification can have no effect on the extent of homophony produced, and therefore the presence of new homophony entails that more homophony than the corresponding additive FLOSS-value is produced. A counter feeding to Type5IF (Condition A) relationship is incompatible with new homophony. In fact, the homophony produced is simply additive for the respective single processes.

Type5IF (Condition B) is also an interactive relationship owing to the Incomplete Feeding relationship.

e.g. Type5IF (Condition B) (WF position)

Process 2: z - s

dz - ds

Process 1: d - t

ds - ts (ex. dz - tz)

In fact, the potential for homophony production is exactly the same for the two Type5IF conditions. This is because the interacting segment sequences (i.e. /tz/ and /ds/ in the above examples) are non-English WF clusters and therefore the emergence of new homophony is not dependent on the presence of different lexical items for the two Type5IF relationships.

e.g. /raidz/ - raids - /raits/; Type5IF(Condition B) interaction
 /raits/ —————> /raits/; A lexical item present in the sample.

The emergence of new homophony for the two conditions is dependent on the presence of the same lexical items and as such the new homophony produced for the conditions is identical. Furthermore, the counter feeding to Type5IF (Condition B) behaves in an identical manner to counter feeding to Type5IF (Condition A). It is therefore not necessary to distinguish between Conditions A and B in relation to Type5IF. It needs to be noted that eventhough Type5IF relationships can be established on the basis of the processes studied, they will not be subjected to the calculation of FLOSS-values and IMH in Chapter 5, since the data sample does not

include inflected lexical items.

4.3.1.2.3 Summary of the Different Types of Feeding Relationships

Before moving on to examine some other kinds of combinations of processes, it is useful at this point to draw some conclusions about the feeding relationships discussed in the previous section. Table 4.2 (overleaf) summarizes the main characteristics of the relationships. This table indicates the potential differential effects of the feeding relationships for FLOSS and multiple homophony. Some references to this differential potential have already been made throughout the discussion. As is apparent from Table 4.2, different types of factors can indicate the different potentials of the relationships. These factors can be summarized as follows:

- (1) Process relationships which are potentially compatible with new homophony and have potential for producing more homophony than the additive FLOSS-value are potentially more detrimental for the functional adequacy of the phonological system than process relationships which are incompatible with new homophony (e.g. compare Complete Feeding with counter feeding to Complete Feeding).
- (2) For process relationships which are potentially compatible with new homophony there is the following differentiation in regard to their effect on functional adequacy. Firstly, when the production of new homophony implies that potentially more homophony is produced than the corresponding additive FLOSS-value then this has a potentially more detrimental effect on the functional adequacy than if the production of new homophony implies that an equal amount or less homophony is potentially produced than the additive value (e.g. compare Type1IF and Type2IF relationships). Secondly, when the production of new homophony implies that an equal amount of homophony to the additive FLOSS-value is produced, then this has a potentially more destructive effect on the functional adequacy than if potentially less or an equal amount of homophony is produced (e.g. compare Type2IF (Condition A) with Type2IF (Condition B)).
- (3) Process relationships incompatible with new homophony for which FLOSS equals the FLOSS-value for the first process when it operates

Table 4.2: Summary of the Main Characteristics of the Feeding and Counter Feeding Relationships Recognized in the Present Study

	Potential.Compatible with new homophony					Incompatible with new homoph.				Max. no. identical homoph. forms	New homo. via	
	pot. for loss	no pot. for loss	new > add val	new = add val	new < add val	hom = FLO Pr1	hom < FLO Pr1	hom = add val	hom < add val		Feed	Con.
<u>CF</u>												
unaltered		*								3	*	
altered	*									3	*	
<u>co-CF</u>												
unaltered						*				2		
altered						*	*			2		
<u>IF</u>												
unaltered			*	*						4	*	*
co-feed			*	*						3		*
altered												
Type1IF (A + B)			*	*	*					4	*	*
co-feed			*	*	*					3		*
Type2IF (A)				*						3	*	*
co-feed				*						3	*	*
Type2IF (B)				*	*					3	*	*
co-feed				*	*					3	*	*
Type3IF (A + B)			*	*	*					4	*	
co-feed								*	*	2		
Type4IF(i) (A + B)				*	*					2	*	
co-feed								*	*	2		
Type4IF(ii) (A)				*						2	*	
co-feed								*		2		
Type4IF(ii) (B)								*	*	2		
co-feed								*	*	2		
Type3+4IF (A)				*	*					3	*	
co-feed								*	*	2		
Type3+4IF (B)				*	*					3	*	
co-feed								*	*	2		
Type5IF			*	*						2	*	
co-feed								*		2		

Key to Table 4.2:

- pot. for loss / no pot. for loss = potential for loss or no loss of homophony as compared to an additive FLOSS-value
- new >, =, < add val = the incidence of new homophony may entail that more, an equal amount or less homophony is produced than the corresponding additive FLOSS-value
- hom =, < FLO Pr1 = the homophony produced either equals or is less than the homophony produced by Process 1 (i.e. the first process) when it operates as a single process
- max. no. identical homoph. forms = the maximum number of identical homophonous forms produced by the process relationships

- new homo. via Feed, Con = new homophony can be produced via Feeding and / or Conspiring
- CF = Complete Feeding
- co-CF = counter feeding to Complete Feeding
- unaltered = Unaltered Process Specification
- altered = Altered Process Specification
- IF = Incomplete Feeding
- A, B = Conditions A, B

as a single process are potentially more detrimental for the functional adequacy than such process relationships when the FLOSS-value is potentially equal or less than the respective additive FLOSS-value (i.e. compare counter feeding to Complete Feeding with an unaltered process specification with counter feeding to Complete Feeding with an altered process specification).

(4) Those process relationships incompatible with new homophony for which the FLOSS-value is simply additive from the FLOSS-values of the respective single processes are potentially more destructive for the functional adequacy than such process relationships for which the FLOSS-value is potentially less or equal to the corresponding additive FLOSS-value (e.g. compare counter feeding to Type4IF(ii) (Condition A) with counter feeding to Type4IF(i) (Condition A)).

(5) Those process relationships incompatible with new homophony for which the FLOSS-value equals either the FLOSS-value of the first process (FLOSS-value of the first process when operating as a single process) or has potential for lower FLOSS-value than the value for the first process has a potentially less detrimental effect on the functional adequacy than such process relationships for which the FLOSS-value is simply additive (i.e. compare counter feeding to Type4IF(ii) (Condition A) with counter feeding to Complete Feeding).

(6) Those process relationships with a potentially higher maximum number of identical homophonous forms have potential for more multiple homophony than those process relationships with a lower maximum number of identical homophonous forms (e.g. compare Type1IF with Type2IF).

(7) Those Incomplete Feeding relationships characterized by either two feeding relationships (i.e. Type3+4IF) or by an Incomplete Feeding and a Conspiring relationship (e.g. Type1IF) have potential for producing more homophony than those Incomplete Feeding relationships which are characterized only by a feeding relationship.

These characteristics of the process relationships giving rise to the predictable relationships outlined can be further differentiated.

(1) Potential compatibility with new homophony correlates with the

presence or absence of a feeding relationship. This correlation is not however perfect owing to the presence of a Conspiring relationship in addition to an Incomplete Feeding one in Type1IF and Type2IF relationships. Furthermore, a feeding interaction present may not have any effect on FLOSS (i.e. Type4IF(ii) (Condition B)).

(2) Incompatibility correlates with non-interaction between the two processes (e.g. counter feeding to Complete Feeding) or with a feeding interaction which has no potential for new homophony when the feeding interaction is the only interaction present (i.e. Type4IF(ii) (Condition B)).

(3) Potential for a lower FLOSS-value than the corresponding additive value or for a lower FLOSS-value than the FLOSS-value for the first process correlates with the alteration of process specifications except for those altered process specifications which cannot have any effect on homophony (e.g. Type2IF (Condition A)).

(4) For those process relationships with altered process specifications which do not in fact have any effect on homophony and which consist of only an Incomplete Feeding relationship (i.e. Type4IF(ii) (Condition A)), the corresponding counter feeding relationships reflect simply additive FLOSS-values. For those process relationships with altered process specifications which can have an effect on homophony and which consist of only an Incomplete Feeding relationship, the corresponding counter feeding relationships reflect potential for less homophony than the corresponding additive FLOSS-value.

(5) With respect to process relationships potentially compatible with new homophony, the maximum number of identical homophonous forms reflects the means by which new homophony and multiple homophony is produced.

(a) Incomplete and Complete Feeding

- The maximum number of identical homophonous forms is three. Type3IF and Type5IF relationships are an exception in that the maximum number of such forms is four and two respectively.

(b) Conspiring

- The maximum number of identical homophonous forms is three (see Section 4.3.1.3, below).

(c) Incomplete Feeding plus Conspiring

- The Maximum number of identical homophonous forms is 4 except for Type2IF for which the maximum number of such forms is three.
- (6) In regard to process relationships incompatible with new homophony, the maximum number of two identical forms reflects the non-interactive operation of the processes.

The predictable relationships holding between combinations of processes and FLOSS and multiple homophony have now been formally outlined. Table 4.3 (overleaf) summarizes the main differences in terms of the potential effect of the relationships on FLOSS. Similarly, Table 4.4 (page 101) summarizes the differing potentials for multiple homophony. While the tables are interpretable in relation to the discussion thus far, and in particular in relation to Table 4.2 (above), a few additional comments are in order.

In regard to Table 4.3, the differential potentials for FLOSS of the respective relationships are based on three main motivations:

- (1) on the potential presence or an absence of an interaction (e.g. CF > co-CF; Table 4.3).
- (2) on the nature of the process specification (e.g. CF Unaltered PS > CF Altered PS; Table 4.3)
- (3) on the potential number of simultaneous interacting relationships (e.g. Type1IF and Type2IF > Type3IF, Type4IF and Type6IF; Table 4.3).

The third motivation needs to be further qualified. The potential simultaneous presence of a feeding and a conspiring relationship increases the potential for higher FLOSS by the fact that there are two interacting relationships which are both potentially compatible with new homophony. Thus, the actual absence of one of the relationships does not render the relationship automatically incompatible with new homophony (e.g. Type1IF and counter feeding to Type1IF). These comments apply also to Type3+4IF relationships.

As is apparent from Table 4.4, the motivations behind the differential potential for multiple homophony are based on two main considerations:

- (1) on the presence or an absence of an interaction (i.e. no interaction, no multiple homophony; e.g. CF > co-CF; Table 4.4)
- (2) on the maximum number of identical homophonous forms and the potential number of simultaneously interacting relationships

Table 4.3: Summary of the different potential effects of the feeding relationships on FLOSS

(1) Complete Feeding (CF)

- (i) CF > co-feed CF
- (ii) CF Unaltered PS > CF Altered PS
- (iii) co-feed CF Unaltered PS > co-feed CF Altered PS

(2) Incomplete Feeding (IF)

- (i) IF Unaltered PS > co-feed IF unaltered PS
- (ii) IF Unaltered PS > IF Altered PS
- (iii) Type1IF > Type2IF, Type3IF, Type4IF, Type3+4IF and Type5IF
- (iv) Type3IF > Type2IF, Type4IF, Type3+4IF(A) and Type5IF
- (v) Type2IF(A) > Type2IF(B)
- (vi) Type4IF(ii)(A) > Type4IF(ii)(B)
- (vii) Type4IF(ii)(A) > Type4IF(i)
- (viii) Type3+4IF(A) > Type3+4IF(B)
- (ix) Type1IF, Type3IF, Type4IF(i), Type3+4IF and Type5IF > co-feed (Type1IF, Type3IF, Type4IF(i), Type3+4IF, Type5IF)

(3) IF Unaltered PS and Type1IF > CF

(4) co-feed (IF Unaltered PS, Type1IF) > co-feed CF

Key: see Table 4.2 above

- > signifies a potential for higher FLOSS

Table 4.4: Summary of the different potential effects of the feeding relationships on multiple homophony

(1) Complete Feeding (CF)

- (i) CF > co-feed CF

(2) Incomplete Feeding (IF)

- (i) IF Unaltered PS > co-feed IF Unaltered PS
- (ii) Type1IF (and Type3IF) > Type2IF, Type3IF, Type4IF, Type3+4IF and Type5IF
- (iii) Type1IF, Type3IF, Type3+4IF > co-feed (Type1IF, Type3IF, Type3+4IF)
- (iv) co-feed (Type1IF, Type2IF) > co-feed (Type3IF, Type4IF Type3+4IF, Type5IF)

Key: see Table 4.2 above

- > signifies a higher potential for multiple homophony

(e.g. IF/Unaltered PS > CF/Unaltered PS; Table 4.4)

In regard to the second consideration, it can be further maintained that two process relationships with the same potential number for maximum number of identical homophonous forms bear differential potential for multiple homophony if one of the process relationships consists of two interacting relationships while the other consists of only one. The actual absence of one relationship does not remove the potential for multiple homophony for the relationship consisting of two interacting relationships. This together with the fact that the potential contribution of two interacting relationships to multiple homophony must be greater than the presence of only one renders the kind of Incomplete Feeding relationships characterized both by a feeding and a conspiring relationship potentially more^{conducive} to multiple homophony than the relationships characterized only by a feeding interaction. Furthermore, on the basis of this consideration it is possible to attribute greater potential for functional inadequacy of IF/Unaltered PS and Type1IF relationships than Complete Feeding relationships (Table 4.3). It must be noted that while Type2IF relationships also consist of two relationships, the Incomplete Feeding relationship does not contribute towards producing more resultant homophony in the interaction.

4.3.1.3 Conspiring Relationships

Throughout the discussion on Incomplete Feeding relationships reference has been made to Conspiring process relationships. These relationships are not interactive relationships per se (see Section 4.1 above). It has been recognized in the literature on child phonology (e.g. Grunwell, 1985; Stoel-Gammon and Dunn, 1985) that processes can conspire to the same sound (e.g. in systematic sound preference or favourite articulation), which in turn "...is clearly indicative of a severe phonological learning disorder, given the communicative inadequacies of the child's pronunciation patterns which must ensue" (Grunwell, 1985:62). It thus follows that Conspiring processes have a potentially destructive effect on the functional adequacy of children's phonological systems.

Two (or more) processes enter a Conspiring relationship if the output segments are identical while the input segments differ.

e.g. $a \rightarrow b$

$c \rightarrow b$

or

Stopping s - t

Fronting k - t

Processes entering such a relationship are clearly potentially compatible with new homophony.

e.g. Stopping s - t and Fronting k - t (WI position)

/sait/ $\longrightarrow$ /tait/

/kait/ $\longrightarrow$ /tait/

/tait/ $\longrightarrow$ /tait/

/si/ $\longrightarrow$ /ti/

/ki/ $\longrightarrow$ /ti/

/ti/ $\longrightarrow$ /ti/

While this potential compatibility with new homophony is upheld even if the Conspiring processes operated in a different place in syllable structure (see Section 4.3.2, below), it is not possible to make any predictive statements about Conspiring processes and functional adequacy for processes operating in such a fashion. Therefore, only Conspiring processes operating in the same place in structure are considered in this section.

Two processes in a Conspiring relationship 'proper' do not enter any other relationships. This distinguishes Conspiring relationships from some of the Incomplete Feeding relationships discussed earlier. Furthermore, a distinction must be drawn between Conspiring 'proper' and Complete Feeding relationships. Even though two processes in a Complete Feeding relationship end up conspiring to the same sound segment, which then renders the relationship potentially compatible with new homophony, Conspiring occurs only as a function of the feeding relationship. This is what distinguishes such relationships from Conspiring relationships 'proper'.

Two processes in a Conspiring relationship (=proper) can also have an altered process specification. The alteration of a process specification depends on the assumption that two-term cluster reduction patterns (in the WI position in the present study) are operative in three-term clusters.

e.g. WI position

Process 1: str - t

Process 2: tr - t (ex. str - st)

The presence of an altered process specification in a Conspiring relationship entails that the presence of new homophony does not necessarily mean that more homophony by comparison with the corresponding additive FLOSS-value for the two processes is produced. As such, Conspiring relationships with unaltered process specifications have potentially more detrimental an effect on the functional adequacy of the phonological system than Conspiring processes with altered process specifications.

The absence of an interactive relationship in a Conspiring relationship results in the ordering of two processes in such a relationship being irrelevant to FLOSS (cf. feeding vs. counter feeding). Furthermore, this is unaffected by the alteration of process specifications. In addition, the nature of the processes in a Conspiring relationship with an altered process specification is such that there is no opportunity for the process specification of either process being altered (i.e. no Condition A and B). As is apparent from the above example, only the process specification of the process involving the reduction of a two-term cluster can be altered and it must be altered if such a process is the first process. Otherwise, the other process becomes vacuous.

e.g. Process 2: tr - t (ex. str - st)

Process 1: str - t

It is now apparent that Conspiring processes can be viewed as operating simultaneously.

As has been pointed out in the discussion on Incomplete Feeding, the maximum number of identical homophonous forms for two Conspiring processes is three. By comparison with Complete Feeding relationships, this figure indicates an equal potential for multiple homophony. In regard to Incomplete Feeding, on the other hand, Conspiring relationships have potential for less multiple homophony than those Incomplete Feeding relationships which consist of both a Conspiring and a Feeding relationship, except, however, Type2IF relationships since these were essentially Conspiring relationships in that the maximum number of identical homophonous forms produced by the appropriate Incomplete Feeding relationships is two.

Furthermore, being potentially compatible with new homophony, the Conspiring relationships produce potentially more homophony than those counter feeding relationships which are incompatible with new homophony. These differences amongst the different process relationships can be summarized as follows:

Multiple Homophony:

IF (include conspiring) > Conspiring

Conspiring > co-feeding CF and IF (incompatible with new homophony)

FLOSS:

IF (including conspiring) > Conspiring

Conspiring > co-feeding CF and IF (incompatible with new homophony)

Table 4.5 (overleaf) summarizes the main characteristics of Conspiring relationships and as such makes the above comparative statements apparent.

The observations made in this section apply to all the processes which consist of contrastive sound segments. One of the processes investigated in the present study, however, consists of non-contrastive sound segments (i.e. Glottal Replacement). When two processes within the process category of Glottal Replacement enter a Conspiring relationship, the maximum number of identical homophonous forms is two owing to nature of the processes.

e.g. WF-position

Process 1: k - ʔ

Process 2: t - ʔ

/mik/ → /miʔ/

/mit/ → /miʔ/

There are no forms of /miʔ/ present in an English lexical sample for the resultant homophonous forms to match with. It is thus apparent that no multiple homophony can be produced and that the potential for homophony for such combinations is less than for the Conspiring processes involving contrastive sound segments.

There is one more point which needs to be recognized in relation to Conspiring processes. This involves the operation of processes in the process category Final Consonant Deletion. The effect of some F.C.D. process combinations on FLOSS and multiple homophony is identical to some processes in a Complete Feeding

Table 4.5: Summary of the Main Characteristics of the Conspiring Relationships Recognized in the Present Study

	Potentially Compatible with new homophony		Maximum number of identical homophone forms
	new homo. >, = add FLOSS	new homo. >, =, < add FLOSS	
Conspiring			
unaltered PS	*		3
altered PS		*	3

Key:

- new homo >, =, < = the production of new homophony may entail that more, less or an equal amount of homophony is produced than the corresponding additive FLOSS-value

relationship. This can be illustrated by the following example:

e.g. WF position

Process 1: t - 0

Process 2: d - 0

/mæt/ → /mæ/

/mæd/ → /mæ/

Process 1: t - d

Process 2: d - 0

/mæt/ → mæd → /mæ/

/mæd/ → /mæ/

Even though from the point of view of functional consequences the two process combinations are identical the operation of one type of process combination rather than another on actual child data may be a reflection of children's way of dealing with the acquisition process. This observation is merely speculative and needs to be investigated in relation to 'real' child data.

4.3.1.4 The Process Relationships and the Phonological Contrasts Missing from the Phonological System

FLOSS is a potential consequence of missing phonological contrasts in the phonological system. Therefore, the predictable relationships between FLOSS and the various process relationships are also reflected in the number and the nature of phonological contrasts missing for the respective process relationships. The number of contrasts missing for the different relationships can be summarized as follows:

(1) Complete Feeding

Process 1: s - t

Process 2: t - d

Contrasts Missing: 3 i.e. s - t; s - d; t - d

Counter Feeding: 2 i.e. s - t; t - d

(2) Incomplete Feeding

IF/Unaltered PS

Process 1: sp - p

spr - pr

Process 2: pr - p (ex. spr - sp)

Contrasts Missing: 5 i.e. sp - p; spr - p; pr - p; spr - pr;

sp - pr

Counter Feeding: 3 i.e. sp - p; pr - p; spr - pr

(3) Conspiring Processes

Process 1: k - t

Process 2: s - t

Contrasts Missing: 3 i.e. k - t; s - t; k - s

For illustrative purposes only one type of Incomplete Feeding relationship is considered here (i.e. IF/Unaltered PS). It is now apparent from the above examples that the potential for new homophony is reflected in the conspiring of the missing contrasts to the same sound segment. This in turn is reflected in the maximum number of identical homophonous forms produced by the various relationships.

4.3.2 Combinations of Phonological Processes Operating in a Different Place in Syllable Structure

In the discussion thus far process relationships operative in the same place in syllable structure and their relationships to functional adequacy have been examined. While combinations of processes which operate at different places in syllable structure (e.g. two context-dependent processes which operate in different contexts, two context-independent processes which operate in different contexts or a context-dependent and context-independent process operating in different contexts) are not process relationships as such, they are potentially compatible with new homophony. More specifically, potential new homophony is produced by virtue of two resultant forms matching with one another and also possibly with a word in the lexical sample.

e.g. Process 1: l - w (WI position)

Process 2: k - t (WF position)

/leit/ → /weit/

/weik/ → /weit/

/weit/ → /weit/

Even though this notation implies a sequential operation of the processes, processes operating in different places in syllable structure can be viewed as applying simultaneously. The actual presence of new homophony entails that more homophony than the corresponding additive FLOSS-value is produced. On this basis, it is then possible to maintain that two processes operating in a different place in syllable structure are potentially more detrimental for the functional adequacy of a phonological system

than processes operating in the same place in structure which have potential for producing less homophony than the additive FLOSS-value or which are incompatible with new homophony.

This chapter has examined the role of process relationships and 'rule' ordering in the assessment of the functional adequacy of children's phonological systems. Firstly, some general concepts and issues concerning rule ordering have been selectively overviewed. Secondly, the role of rule ordering in the literature on child phonology has been discussed. On the basis of these two sections, it was then maintained that while the notion of rules ordered to reflect specific child realizations is not applicable to the present study, the phonological processes investigated can be viewed as being capable of entering different process relationships of which some can be considered ordering relationships. These relationships were then assessed with regard to their potential compatibility or incompatibility with new homophony. These in turn were considered indicative of a potential for greater or lower FLOSS and IMH. These considerations provide the basis for making predictions about the potential effect of the process relationships on FLOSS and multiple homophony. It has also been recognized that while the predictable relationships between the process relationships and FLOSS/multiple homophony are correlated with phonological processes in the present study, the relationships are essentially reflections of the contrasts missing in the phonological system. Furthermore, it is maintained that for a process relationship to be potentially compatible with new homophony, the contrasts which are missing from the phonological system must conspire to the same sound segment. Finally, in addition to process relationships, it has been recognized that two processes operating independently in different places in syllable structure are also potentially compatible with new homophony. These observations are potentially relevant to the actual analysis of child data. These issues will be discussed in more detail in Chapter 6.

Chapter 5: Calculation of FLOSS-values and indices of multiple homophony for phonological processes.

In this chapter FLOSS-values and indices of multiple homophony are obtained for phonological processes commonly found to operate in the speech of both phonologically normal and disordered children. The functional adequacy of such phonological systems is assessed in relation to a lexical sample which reflects the 'basic' vocabulary of children with normally developing language. The data sample and the method of analysis, including a description of the processes chosen for the study, are examined in detail in Sections 5.1 and 5.2 respectively. The actual calculation of FLOSS-values and indices of multiple homophony is divided into two separate 'studies'. Study 1 reflects a situation in which only one process (with a restricted definition of the term process; see Section 5.2.1, below) operates at a time on the sample. Context-independent processes (see Section 5.2.1) may, however, operate in different places of syllable structure simultaneously. This in turn implies potential for multiple homophony. Study 2, on the other hand, examines the operation of two processes either in the same place in syllable structure or in different places in syllable structure. Both of these situations have potential for multiple homophony (see Section 4.3, above). Studies 1 and 2 are described in Sections 5.3 and 5.4 respectively.

While the functional inadequacy of incomplete phonological systems can be assessed on the basis of a multitude of different combinations of phonological processes, for purposes of a practical analysis the present study had to restrict itself to considering only a selection of possible 'states' of an incomplete phonological system reflected in the operation of the processes studied. It was decided that the calculation of FLOSS-values (and IMH) for single phonological processes (ie. Study 1) could provide useful data for use in the clinical context by enabling the calculation of FLOSS-values for non-interacting 'combinations' of processes (FLOSS-value simply additive; see Chapter 4). In addition, the consideration of the combinations of only two processes would enable a more exhaustive analysis to be carried out. This would also reflect the theoretical framework introduced in Chapter 4.

5.1 The Data Sample

The data sample for the present study reflects the 'basic' vocabulary of children with normally developing language. Basing the study on a normal sample promotes its wider applicability. The close similarity of normal lexical development to the development of vocabulary in children with disordered phonologies (see below), renders the results relevant to both normal and disordered populations. Also, the phonological processes selected for analysis characterize the speech of both normal and phonologically disordered children (see Section 5.2.1, below). However, the choice of the data sample was also affected by the availability of appropriate vocabulary samples. No published samples of the vocabulary of children with phonological disability exist. To compile such a sample would most likely prove very problematic as it would be difficult and time consuming to obtain glossable, spontaneous speech over a period of time from a homogeneous group of these children.

It is recognized that children with language impairment typically acquire words at a later stage and take longer in learning how to use these words than their peers with normally developing language (e.g. Nice, 1925; Weeks, 1974; Leonard, 1979; Weiner, 1979; Kail et al, 1984). Their vocabularies tend to be comparable in size and nature to those of younger normal children (e.g. Snyder, 1979; Leonard and Fey, 1979). For example, comparison of the first fifty words used by eight language disordered children aged 2;7-3;6 with 18 normal children, show indeed that the types of lexical items used by the two groups are very similar (see Table 5.1 below).

Table 5.1: The Mean Percentages of Word Usage by Eight
Language Disorderd Children Studied by Leonard (1977)
and Eighteen Normal Children Studied by Nelson (1973)

	Specific Nominal	General Nominal	Action	Modifier	Personal Social	Function
Language Disorderd	10	49	22	10	6	3
Normal	14	51	13	19	8	4

(from Leonard and Fey,1979:120)

Whereas some doubt must be cast on the homogeneity of the groups of children studied, it seems reasonable to conclude from studies such as the above, that the early word usage of language impaired children is indeed fairly normal in nature. What, however, seems to characterize their lexical development as different from normal is late onset of acquisition. In a report of fifteen language disordered children, Morley, Court, Miller and Garside (1955), for instance, noted ages of first word acquisition ranging from 1;6 to 5;0. Subsequent lexical development is also reported to be slow (e.g. Nice,1925; Weeks,1974).

Since there are no studies addressing the issue of lexical development in children with phonological disability, the results obtained from the general groups of the language impaired will of necessity have to be considered applicable to the phonologically impaired children. There is reason to suppose, that difficulty in acquiring the sound system of language will at least hinder, if not disrupt, the development of lexical, syntactic and functional skills (e.g. Winitz, 1969; Grunwell, 1981; Paul and Shriberg, 1982).

It^{is} thus possible to suppose that a vocabulary sample from a normal population of young children is a fair reflection of the vocabularies of older children with phonological disability. It is yet another task to determine what constitutes a fair representation of the vocabulary of a particular age group. Whereas Fry (1979:34) writes that "...the average child remains a figment of statistical

imagination", he, amongst others, gives a 'rough' guide of vocabulary growth (see Table 5.2 below).

Table 5.2: Vocabulary Growth in Children

Age	Number of words		
	Smith (1926)	Fry (1977)	Cruttenden (1979)
2;0	272	200	500
3;0	896	1000	
4;0	1540	2000	
5;0	2072		2000
6;0	2562		
7;0			4000

As can be seen in Table 5.2, there is certain agreement as to the number of words in children's vocabularies between the three publications. The differences most likely reflect differences in subject populations, sampling procedures and research methodologies.

The task of this part of the present study was to obtain a normal data sample of about 2000 words reflecting the vocabularies of four to six year olds. The sample should also be of spoken rather than written language, since the kinds of patterns to be studied are operative in the spoken medium of language. Two published word counts based on the spoken language of children were available: Burrough (1957) and Wepman and Haas (1975). Table 5.3 (overleaf) compares these two as regards three parameters: 1. The subjects used 2. The method of data collection 3. The results obtained. Whereas neither sample is totally satisfactory, the Wepman-Haas data is less adequate due to (i) being non-spontaneous; based on a picture test (ii) being obtained in a single session (iii) the small number of children per group (30) (iv) the number of words obtained not corresponding to the general conception of vocabulary size for the ages concerned. The main weak points of Burrough, on the other hand, are not so serious in regard to the representativeness of the sample. It may however be criticised for (i) being out of date (1957) (ii) manual recording of the data (iii) lack of information about the word class status of words (iv) the number of different observers (165 - one person per child dyad).

Since it was beyond the scope of the present study to obtain an

Table 5.3: Comparison of Burrough (1957) and Wepman & Haas (1975)

	Burrough (1957)	Wepman/Haas (1975)
Subjects-age	5;11-6;11	5;0, 6;0, 7;0
-number of	350; 165 M/F	90; 30/group; 15 M/F
-nationality	British	American
Method		
-data obtained	spontaneous + structured spontaneous	Thematic Apperception Test (Murray,1943)
-data recording	165 observers recorded every 'fresh word' by hand-orthographic	tape recording- orthographic transcription
-duration	each child seen 11 times for 10 minutes for two weeks	single session
Results		
-no. of	List 1-1909 (used by more than 1.5% of the test population) List 2-1595 (used by less than 1.5% of the test population)	5 years-740 6 years-890 7 years-1000
-organization	into two lists as above -no information about word class membership or frequency	by age group; information about mean frequency of words used, varience, word class, number of subjects using a word

ideal data sample, it was necessary to overlook the shortcomings of Burrough's data collection. These inconsistencies should not however prove detrimental for the present study, which aims to be illustrative rather than conclusive in nature. The date of the sample should not prove too problematic. It can be argued, that the vocabulary of the child of the 1980's must be somewhat different from that of the 1950's, due to advances in technology and changes in social, cultural and economic conditions. However, the extent of vocabulary growth may be considered fairly stable over the years. The figures in Table 5.2, above, are not indeed very much different for the studies conducted in the 1920's as compared to the 1970's.

Burrough provides two word lists: List 1 consists of some 1909 words which are used by five or more of the test population and List 2 consists some 1595 words used by four or less of the subjects. Only the words in List 1 are used in the present study. It was felt that many of the words in List 2 were clearly outside the domain of 'basic' vocabulary of the ages concerned (e.g. abscess, arboretum, celluloid, impetigo, quern), especially if considered in relation to the delayed vocabulary development of the language impaired children. Nevertheless, there are also words in List 2, which are clearly commonly used by young children (e.g. busy, cheap, dance, fool, gorilla). However, there is no scope in the present study to differentiate between the more 'common' (or frequently occurring) and the less 'common' words.

The words in List 1 have been stored in a computer, in a phonemic form with primary stress and syllable boundaries marked (The data sample in Appendix 1; See Section 5.2.2 for a detailed description of the computing part of the study.). The phonemic transcription of the words was based on Gimson (1977). Certain words and forms in List 1 were excluded from the study (see Appendix 2). These words fall into five categories:

1. Interjections (e.g. hush, baa, aye, hey, oh)
2. Items comprising two or more orthographic words (more than one primary stress) (e.g. Union Jack, fishing rod, dressing table)
3. Shortened forms of two words (e.g. aren't, couldn't, I've)
4. Words referring to old currency (e.g. farthing, halfpenny, halfcrown)

5. Miscellaneous (e.g. Miss, Mrs, Mr)

There are some other points about the data sample which need be discussed here. The first point concerns words which are commonly viewed as possessing both a strong and a weak form (e.g. have, has, as, at). Since these forms differ in terms of the 'strength' of the vowel, they are not of crucial importance for the implementation of the phonological processes on the data sample (see Section 5.2.1, below). Nevertheless, the marking of the strong or the weak form throughout the data needed be uniform in order not to distort the extent of homophony produced in the lexical system through the operation of processes. Thus, all respective words were stored in their strong forms, as specified in Gimson (1977). Secondly, all the words are transcribed as in careful, slow speech (e.g. handbag - /hændbæg/ not /hæmbæg/). It was decided that an attempt to account for pronunciations as encountered in rapid speech, and in differing contexts, would lead to too many inconsistencies in the recording of the data.

As was mentioned previously, the words were stored with syllable boundaries marked. The establishment of syllables and syllable division in words is not however a straightforward task. The concept of the syllable has a controversial history in the development of phonological theory. The numerous attempts to give it a rigorous phonetic and/or phonological definition (e.g. O'Connor and Trim, 1953; Pulgram, 1970; Hoard, 1971; Khan, 1976; Rudes, 1977; Anderson and Jones, 1974; Bailey, 1978; Hooper, 1976) have not been entirely successful. There are two basic kinds of phonological theories. The most usual theory assumes that syllables can be defined and located in terms of existing segments and words (e.g. Pulgram, 1970; Hoard, 1971; Khan, 1976; Anderson and Jones, 1974; Rudes, 1977; Bailey, 1978). The other main type assumes the syllable, like the segment, to be an independent construct, part of the characterization of an utterance (e.g. Fudge, 1969; Hooper, 1976). There is also a third class of theories of segment organization which do not insist upon syllables at all (e.g. Goldsmith, 1976). They merely assume 'bonds' among segments constituting their organization. In a sense, such a theory is not much different from the syllable theories, since segments with a common 'bond' are said to belong to the same syllable.

However conceptualized, all the phonological theories must be capable of resolving the same basic questions about the characterization of syllable structure. The assignment of segments to syllables, or syllabification/syllabication, is keenly debated. Current theories seem to describe syllabification of words according to certain rules. Most theories agree, as their starting point, that syllables observe the same phonotactic constraints that words do. Some go a step further (e.g. Hooper, 1976; Rudes, 1977) by observing also a sonority hierarchy of consonants in syllabification.

Most theories also adhere to the principle of 'maximal onset', which claims that the maximum number of consonants, allowed by the phonotactics of the language, are allocated to the syllable initial position. Pulgram (1970), for instance, syllabifies solely according to the maximal onset and minimal coda principle. There are others (Khan, 1976; Rudes, 1977; Hoard, 1971; Bailey, 1978), who in addition to the maximal onset principle, modify syllabifications according to surface stress. The stressed syllable is analysed as attracting the maximum number of consonants in both initial and final positions.

The final rule commonly applied in syllabification concerns ambisyllabicity. This is the sharing of intervocalic consonants by neighbouring syllables. There are different degrees of tolerance for ambisyllabicity in syllable theories. Anderson and Jones (1974), for instance, allow ambisyllabicity whenever possible, whereas Bailey (1978) allows it only for liquids, glides and 'phonetically long consonants'.

Much of the support for syllabification comes from theoretical studies of language. There is, however, an interesting experimental study by Fallows (1981). It aimed to examine the use of the main principles of syllabification by two groups of American-English speaking children: 9-10 year olds and 4-5 year olds. The main results showed that

- (i) the phonotactic constraints of words were observed 98% of the time
- (ii) lax vowels were closed 70% of the time, of which 85% in stressed syllables and 35% in unstressed syllables
- (iii) stressed syllables attracted 74% of the maximum number of

consonants in both initial and final positions - 93% in syllable initial position in words in which primary stress fell in the second syllable; 55% in syllable final position in words in which primary stress fell in the first syllable
(iv) maximal onset applied 71% of the time - 94% to stressed syllables, 66% to unstressed syllables

(v) Ambisyllabicity applied 22% of the time, mainly when two rules were in conflict and it applied mainly to liquids and nasals.

The theories outlined above accommodate these findings to varying degrees. All the theories however prefer the syllable shape CVC, thus not discriminating between lax and tense vowels.

The approaches to syllabification adopted in the clinical literature on phonological assessment (e.g. Ingram, 1981; Crystal, 1982; Grunwell, 1985), apply the principles put forward by syllable theories in different ways and to different degrees. These procedures are necessarily 'simplified' to facilitate speed and accuracy in the recording of clinical data. All three procedures propose a rule which divides compound words according to their lexical structures (e.g. /ti,spun/). As regards intervocalic singleton consonants and consonant sequences, Ingram and Crystal allow ambisyllabicity, whereas Grunwell divides such patterns into ,C- -C,C-, -C,CC-, -C,CCC- etc structures, provided no phonologically implausible or impossible initial or final consonants result. In Ingram's procedure ambisyllabicity is only operational, if the intervocalic consonant sequences are permissible word final sequences in English, where permissible does not necessarily imply occurrence. By contrast to both Ingram and Grunwell, Crystal proposes a rule, which places syllable boundaries on the basis of morphological boundaries (e.g. /rʌn,tʃ/). Crystal also takes stress into account "when a stress pattern clearly motivates a syllable division" (p.67) (e.g. /tæk,sɪ/). Both Crystal and Ingram have a rule which places a syllable boundary between unstressed and stressed syllables, when the former precedes (e.g. /ə,'gæn/; /bɔ,'lʌn/). Grunwell does not take stress into account. All three ignore vowel quality.

On the basis of the considerations outlined so far, the task of the present study was then to arrive at a 'workable' procedure for syllabification. In regard to the clinical angle of the study, it

was desirable to operate rules similar to those found in the clinical literature, rather than to arrive at more complex principles based on the current theories of syllable structure and on current experimental evidence. The computerization of the analysis also affects syllabification by disallowing ambisyllabicity (see Section 5.2.2). By following some of the procedures established in syllable theories and some utilized in clinical analysis, the following rules of syllabification were observed in the present study:

- (i) A syllable boundary is placed between unstressed and stressed syllables, when the former precedes (e.g. /ə, 'qən/).
- (ii) Compound words are separated by syllable boundaries according to lexical structures (e.g. /'ti, spun/).
- (iii) Phonotactic constraints of consonants in words are observed above all other principles (e.g. /hæŋ, ɪŋ/).
- (iv) The principle of maximal onset is observed for intervocalic single consonants (e.g. /wɔ, kɪŋ/ ; /peɪ, pə/).
- (v) Intervocalic consonant clusters are divided so that a single consonant occupies the syllable final word medial position and the remaining consonants the syllable initial word medial position (e.g. /'bas, kɪl/ ; /'mɪn, stə/). These rules are effectively the same as those proposed by Grunwell (1985).

5.2 The Method

5.2.1 The Phonological Processes Investigated in the Study

In order to acquire the widest possible applicability for the results of the present study, processes which are reported as commonly characterizing the speech of both normal children and children with disordered phonologies were included in this study. Table 5.4 (overleaf) shows an overview of published authorities meriting commonness of certain processes. Table 5.4 summarizes a short survey of five assessment procedures aimed at the phonologically disordered population (i.e. Weiner,1979; Hodson,1980; Shriberg and Kwiatkowski,1980; Ingram,1981; Grunwell,1985), of three articles examining phonological processes in phonologically disordered children (i.e. Hodson and Paden,1981; McReynolds and Elbert,1981; Dunn and Davis,1983) and a survey of 16 common processes encountered in both normal and disordered speech (Khan, 1982).

It was assumed that the assessment procedures would reflect the kinds of processes that clinicians would more readily identify in disordered speech and therefore that basing the present study on these procedures would make for wider applicability. Ingram and Weiner include common processes found in the speech of both normal and language disordered children in their assessment procedures. Grunwell states explicitly that the processes in her procedure are attested as occurring most commonly in early normal child phonologies except for Glottal Replacement and Glottal Insertion, which are more typical of disordered development than of normal development. Hodson and Shriberg and Kwiatkowski include processes commonly found in language disordered speech in their procedures.

It is not always clear what exactly is meant by a 'common process' in the literature. Common processes most likely refer to those processes most frequently evidenced in the studies of normal or disordered children's speech. Shriberg and Kwiatkowski base their choice of eight processes on two more criteria in addition to the criteria of 'commonness'. They state that a process must be 'natural' and conducive to reliable scoring by clinicians. 'Naturalness', in turn, is determined by two conditions: A natural process (i) accomplishes simplification (ii) is widely attested in natural language data. Simplification changes a more complex

Source	Phonological Process	
Weiner, 1979	X	Cluster Reduction
Hodson, 1980	X	Weak Syllabic Deletion
Shriberg & Kwiatkowski, 1980	X	Stopping - fricat./affric.
Ingram, 1981	X	Stopping - liquids
Grunwell, 1985	X	Fronting
Hodson & Paden, 1981	X	Gliding of liquids
McReynolds & Elbert, 1981	X	Vocalization
Khana, 1982	X	Final Consonant Deletion
Dunn & Davis, 1983	X	Consonant Harmony
Totals	9	Reduplication
	8	Prevoalatic Voicing
	5	WF Devoicing
	3	Voice WI C's; Devorce WF C's
	9	Global Replacement
	7	Global Insertion
	9	Affrication
	7	Deletion of WI C's
	5	Backing
	6	Denasalization
	5	Gliding of fricatives
	1	Coalescence
	2	Deaffrication
	1	Labialization
	1	Apicalization
	1	Frication of Stops
	1	Deletion of segments
	2	Stridency Deletion
	2	Liquid Simplification
	2	Velar Omissions
	1	Substitution of C's in clusters
	1	Depalatalization
	1	Unvoiced C's → voiced C's before voiced C's

Table 5.4: Overview of Phonological Processes

articulatory structure at the underlying level (=adult form) to a less complex structure at the surface level (=child realization). This requirement, according to Shriberg and Kwiatkowski, exempts phonetic distortions and additions from the analysis. Furthermore, voicing processes (e.g. WF Devoicing; Prevocalic Voicing; combination of the two) are left out due to the possibility of unreliable discrimination of voicing differences by clinicians (see Section 2.2 above). Glottal replacement is excluded for the same reason. Reduplication, on the other hand, is left out due to its low frequency in Shriberg and Kwiatkowski's speech samples.

The articles chosen for the present survey examine the use of processes by groups of children rather than focus on individual cases. There are many other studies and surveys on occurrence of phonological processes which however tend either to be selective in the patterns studied (e.g. Leonard, Miller and Brown, 1980 - Consonant Harmony and Reduplication; Ingram and Terselic, 1983 - Final Ingression; Farwell, 1972 - fricatives) and/or concentrate on small numbers of children (e.g. Compton, 1975; Schwartz et al, 1980; Lorentz, 1974; Grunwell, 1981). Hodson and Paden (1981), McReynolds and Elbert (1981) and Dunn and Davis (1983) focus on the use of phonological processes by groups of children.

In their study of 60 unintelligible children (CA=3;0 to 8;0), Hodson and Paden identified five processes which were used by 50-60 children: Cluster Reduction (e.g. /skɪn/ → [kɪn]), Stridency Deletion (e.g. /sɪn/ → [hɪn]), Stopping (e.g. /fɪn/ → [pɪn]), Liquid Simplification (e.g. Vocalization of the syllabic /l/ - /bɒt/ → [bɒtə]; Stopping of /l/ - /ɪt/ → [pɪt]; Omission of the Liquid - /dɒl/ → [dɒ]) and Assimilation (e.g. /dɒg/ → [gɒg]). Six other processes were used by 30-40 of the children: Velar Deviation (mainly Fronting, /kaɪt/ → [tɪt]), Final Consonant Deletion (e.g. /keɪk/ → [keɪ]), Unstressed Syllable Reduction (e.g. /bə, 'lun/ → [lun]), Prevocalic Voicing (e.g. /pɪn/ → [bɪn]), Glottal Replacement (e.g. /bɪ, ɔə/ → [bɪ, 2ə]) and Backing (e.g. /bæɪ/ → [bæk]). McReynolds and Elbert (1981) reported similar results in their study of 13 phonologically impaired children (CA=3;7 to 13;0 averaging 6;5) in their quantitative criteria analysis. It was decided in the present study to select only those processes used by 2 or more children in McReynold

and Elbert's quantitative criteria analysis into Table 5.4. This decision is an arbitrary one.

Whereas McReynolds and Elbert indicate the presence or absence of a process in individual children, they along with Hodson and Paden fail to present information about frequency of process occurrence in individual cases. As Dunn and Davis (1983:189) point out, without such information it is not possible to determine which processes are truly most characteristic of disordered phonology. They remedy the situation by quantifying the frequency of occurrence of normal and unusual processes in nine disordered children (CA=3;8 to 5;10), in addition to describing patterns of process occurrence. The frequency of process occurrence was computed for each process for each child by dividing the number of actual occurrences of each process by the number of potential occurrences. Whereas there were six processes which characterized majority of errors in the disordered population in question there was a great deal of variation in the frequency of occurrence amongst the children. For instance, the range of occurrence for Velar Fronting for the group was 0-73%. However, for five children the range was 0-16% and for the remaining four 54-73%. It is thus clear that the failure to observe individual frequencies of processes may easily lead to misleading conceptions of what constitutes a common process.

There are several other reservations which need be born in mind when interpreting Table 5.4. The definitions and categorizations of processes seem to vary considerable from author to author. For instance, the demonstration of assimilation by all of Hodson and Paden's children, but by none of Dunn and Davis' subjects, may have resulted from the fact that Hodson and Paden included all manner and place classes, which result in one sound becoming another, within the process assimilation. Dunn and Davis, on the other hand, considered only velar and labial consonants in this connection.

The categories of processes are not always mutually exclusive or they consist of patterns which are describable by separate processes. For instance, McReynolds and Elbert, following Ingram (1976), include a process category which is characterized by substitution of one of the consonants in a cluster by another consonant. The pattern /plein/ → /pwein/ would be included in this

category. It could, however, be equally well classified as 'gliding of the liquid'. Similarly, Hodson's, and consequently Hodson's and Paden's, stridency deletion in clusters (e.g. /sta/→/ta/) is often classed as Cluster Reduction by others (e.g. Grunwell, 1985).

McReynolds and Elbert (1981) take this a step further by showing how differences in the criteria for phonological process analysis may lead to differing conceptions of common processes. Processes identified in speech samples differed markedly as a function of the number of pattern occurrences required for recording of a process. The number of processes identified decreased by more than 50% when the specific error had to have an opportunity to occur in at least four instances and had to occur in at least 20% of the items that could have been affected by the process before being taken to characterize the process, rather than when only one occurrence of the error was required for process category membership. It is not always clear in the literature, what criteria for the identification of processes are used.

The results of studies examining phonological processes in children may be further affected by the age of the subjects. The fact that McReynolds and Elbert (1981) and Dunn and Davis (1983) reported virtually no occurrences of Reduplication and Assimilation (Consonant Harmony in Table 5.4), whereas Hodson and Paden (1981) did, may be due to some younger subjects in Hodson and Paden's study (CA=3;0-8;0). These two processes are said to disappear very early from normal children's speech (e.g. Ingram, 1976; Grunwell, 1982). The sample type and size also have an effect on the process categorizations.

Bearing in mind the reservations outlined above, Table 5.4 shows a clustering of processes which have been 'commonly' encountered in the speech of the normal and disordered child population by the respective authorities. Those processes considered common by four or more investigators were initially chosen for the present study: Cluster Reduction, Weak Syllable Deletion, Stopping of Fricatives and Affricates, Fronting, Gliding of Liquids, Vocalization, Final Consonant Deletion, Consonant Harmony, Reduplication, Pre-Vocalic Voicing, Word Final Devoicing and Glottal Replacement. Not all of these processes were however suitable for

the present study due to methodological considerations.

Due to computational considerations (see Section 5.2.2 below), certain restrictions had to be imposed on the type of processes which can be subjected to analysis. These restrictions do not however undermine the potential value of the study. First of all, the computer system employed did not allow one to manipulate segment strings which cannot be easily specified. In regard to Weak Syllable Deletion, it would be necessary to specify every possible segment sequence making up the unstressed syllables separately, which would be a too cumbersome task. It would involve scanning through the data sample for unstressed syllables and then manually specifying each syllable in the analysis (see Section 5.2.2 below). This problem is compounded in relation to Reduplication. In order to be able to study the functional consequences of this process it would be necessary to separately (and manually) replace every syllable in a word other than the first syllable by the first syllable. This indeed would be a too time-consuming task. Therefore, these two processes are excluded from the study.

Secondly, the computer method used in the analysis did not enable one to analyse context-sensitive operations (see below) in which the operation depends on intra-word contextual considerations. For instance, in order to be able to carry out the operation of Consonant Harmony on the data sample it would be necessary to specify that certain segments need to be present in addition to the segment that is being affected on a word. It is not possible with the present computing resources to carry out such implicational operations (i.e. If X and Y in a word (and possibly in specifiable positions), then substitute Y by Z). Thus, Consonant Harmony is excluded from the present study.

Finally, while it is possible to carry out the operation of Vocalization, in that it is a context-free process and involves only the manipulation of one segment, it is not particularly meaningful process to study when assessing functional adequacy . It does not have the capacity to produce much, if any, homophony when it operates in the lexical system either on its own or in a combination with another process. Homophony can be produced only by there being a matching word on the data sample, and this in light of the nature of the process does not appear very conducive to homophony

production. Furthermore, Vocalization cannot enter into process relationships with any other of the processes except if we consider the operation of process combinations in different places in syllable structure (see Section 4.3.2). Therefore, Vocalization is excluded from the study.

While the restrictions on the inclusion of processes in the study are largely procedurally motivated, the exclusion of Consonant Harmony and Reduplication can be further justified on the basis of developmental considerations. These two processes are developmentally early processes (see Grunwell 1982:183 - chronology of phonological processes). As such they are likely to operate on a word in combinations with more than two processes, while the present study considers only the maximum number of two combined processes. Thus, in order to avoid totally unrealistic patterns in this study, (e.g. Reduplication: /prɜk,tɪs/ → /præ k,præ k/) these two processes can be justifiably excluded.

The remaining eight processes will now be further specified in order to establish the exact substitutions and deletions that were carried out on the data sample. The literature surveyed in Table 5.4 was used to establish of more detailed descriptions of the processes. Additionally, several other published accounts of normal and disordered phonologies were consulted (e.g. Renfrew 1966; Compton, 1970; Edwards and Bernhart, 1973; Smith, 1973; Lorentz, 1974, 1976; Panagos, 1974; Salus and Salus, 1974; Drachman, 1976; Ingram, 1975, 1976; Leonard, 1978; Maxwell, 1979; Smith, 1979; Schwartz et al, 1980; Fee and Ingram, 1981; Weiner, 1981; Grunwell, 1981, 1982, 1985; Locke, 1983; Stoel-Gammon and Dunn, 1985;). Appendix 3 summarizes the details of the phonological processes included in this study. General comments to amplify these details are made below.

Cluster reduction is taken to refer to the deletion of a member of a word initial consonant cluster. Consonant clusters in word medial and final positions were excluded from the analysis. The treatment of cluster reduction in the literature in positions other than the word initial is too inconsistent to enable the construction of comprehensive and explicit commands for a computer analysis (see below). As regards WI clusters, however, there is agreement in the literature as regards the following: (i) plosives tend to be

retained in clusters (e.g. /stop/→/top/) (ii) /s/ tends to be deleted in clusters (e.g. /stɪk/→/tɪk/) (iii) sonorants tend to be omitted in clusters (e.g. /slip/→/sip/).

There seems to be general agreement in the literature as to what constitutes stopping of fricatives and affricates. It is taken to refer to the substitution of homorganic stops for fricatives and affricates. Similarly, fronting commonly refers to velar and palato-alveolar fronting. Whereas there are some more unusual patterns of fronting reported in the literature (e.g. Hodson, 1980 describes fronting as involving the substitution of /k, g/ by either [t, d, n] or [p, b, m].), it is usually taken to refer to the substitution of velar plosives by the corresponding alveolar plosives. The palato-alveolar affricates are commonly fronted to [ts] and [dz] (e.g. Grunwell, 1985). These are however excluded from the analysis in that these processes have no potential for homophony production when operating as single processes. There are no words with the word initial consonant clusters /ts/ or /dz/ in the data sample consisting of English words and therefore there are no words for the resultant forms to match. Similarly, /ts/ and /dz/ clusters in the SFWF position involve grammatical inflections and thus there is no potential for homophony in the present data sample which consists of non-inflected lexical items only. Furthermore, these processes cannot enter into process relationships with any of the other processes studied.

Gliding of liquids is taken to refer to the replacement of the liquids /l, r/ by the glides [w, j]. Some authors include gliding under a general category of liquid simplification (cf. Table 5.4).

Prevocalic Voicing is taken to refer to the replacement of prevocalic voiced obstruents by their voiceless counterparts. Thus, Prevocalic Voicing is operative in the SIWI and SIWW (see below) places in structure (but see Section 5.4).

Glottal Replacement refers to the replacement of consonants by a glottal stop. It can operate in all places in syllable structure. Because of the great number of operations that this could generate for the present study (in light of the computing resources, see Section 5.2.2 below), it was decided to consider only the operation of this process in the word final place in structure. This indeed

is a common pattern in children's speech. Furthermore, it is not relevant to study Glottal Replacement as a single process (i.e. in Study 1; Section 5.3). There is no possibility for homophony production in the present data sample which reflects non-regional pronunciation patterns, since there would be no words consisting of a glottal stop for the resultant forms to match with (see also Glottal Replacement in combinations with other processes; Section 5.4 below).

Final Consonant Deletion is taken to refer to the deletion of WF obstruents and nasals. Grunwell (1985) includes the deletion/reduction of WF clusters as a separate entry in her assessment procedure. It is not, however, at all clear in the literature how these clusters are systematically reduced in child speech. There are only a small number of observations in the literature on the reduction of word final clusters. Smith (1973) observed his son A's tendency to delete nasals in word final clusters before voiceless consonants (eg /dʒʌmp/ → /dʒʌp/, but /mend/ → [men]) (also Edwards and Bernhart, 1973; Grunwell, 1977). There are also a few examples of s-loss in word final clusters (e.g. Maxwell, 1979 - /foks/ → /fot/; Salus and Salus, 1974 - /bast/ → /bat/). These small scale observations are not however adequate for explicit specification of deletions for a computerized analysis. Thus, word final clusters were reduced according to the patterns of reduction of single consonants. That is to say that if word final /k/ were to be deleted this would apply both to words containing a single /k/ in the word final position and to words with a word final consonant cluster consisting a /k/ (e.g. /teik/ → /tei/; /nekst/ → /nest/). It was not possible to delete whole word final clusters with the present computing resources.

Word final devoicing is taken to refer to the replacement of word final voiced obstruents by their voiceless counterparts. As regards devoicing of consonants in word final consonant clusters, there are virtually no reported examples of this occurring in child speech. This may be due to either its usual co-occurrence with other processes (i.e. an early process) or to its operation on word final singletons only. Because of the indecision as regards this matter, and because of restrictions on the computing resources (see section

5.2.2 below), all obstruents in the word final place are devoiced irrespective of their status as singletons or as part of clusters.

The actual implementation of the patterns established on the data sample needs to be qualified further. This qualification hinges upon the 'context-independent' nature of certain processes. The term 'context-independent' will be distinguished from the term 'context-free', which is commonly encountered in the literature on phonological processes (and phonological rules; see Section 4.1 above). A 'context-free' process, as opposed to a 'context-sensitive' one, refers to the independence of substitutions or deletions of phonemes from other phonemes in a word (e.g. Stampe, 1979). A 'context-independent' process, on the other hand, will be taken to refer to the independence of the process of the syllable structure of a word. That is to say that a 'context-independent' process can operate on any place in syllable structure separately or simultaneously (see below). A process, the operation of which is tied to a particular place in syllable structure, is then referred to as a 'context-dependent' process. Defined as such the two sets of terms are not mutually exclusive but they do provide a useful way (for the present analysis) of describing the nature of phonological processes.

With the limited information in the literature about the status of processes as regards these four categories, it is not possible to determine with any certainty for all the eight processes in question which ones are context-free or context-sensitive, or context-independent or context-dependent. Context dependence can however be ascribed to Word Initial Cluster Reduction, Word Final Devoicing, Final Consonant Deletion and Prevocalic Voicing in that they operate on specified and limited places in syllable structure only. Similarly, Fronting, Stopping, Gliding and Glottal Replacement can be considered context-independent, in that they can operate in any place in syllable structure. However, Glottal Replacement is treated as context dependent in the present study (see above). Cluster Reduction can apply context independently in child speech, but due to lack of information about the operation of this process in places other than the word initial, it is treated context dependently in the present study. All the eight processes selected for the analysis are treated as primarily

context-free, even though it is recognized that they may function context sensitively in the speech of children. Table 5.5 below, summarizes the status of the eight processes as regards their context sensitivity and context independence.

Table 5.5: The Status of the Eight Processes

	Context Independent	Context Dependent
Context	Fronting	Cluster Reduction
Free	Stopping	WF Devoicing
	Gliding	Final Consonant Deletion
		Prevocalic Voicing
		Glottal Replacement

It is useful to make the distinction between context-independent and context-dependent processes in the present study. It determines the number of operations to be carried out for any one process. Since context-independent processes can operate on any one place of syllable structure only or on several places simultaneously, this needed to be taken into account in the analysis. Following Grunwell (1985), four places of syllable structure were recognized: Syllable Initial Word Initial (SIWI), Syllable Final Within Word (SFWW), Syllable Initial Within Word (SIWW), Syllable Final Word Final (SFWF). For the three context independent processes, namely Fronting, Stopping and Gliding, the following separate operations were carried out: The relevant substitutions were implemented (i) on SIWI place in structure only (ii) on SFWW place in structure only (iii) on SIWW place in structure only (iv) on SFWF place in structure only (v) on all the four places of structure simultaneously. To take an example, the fronting of /k/ was carried out five times, so that

- (i) all /k/ in the SIWI place only were substituted by /t/ (e.g. /kɪk/ → /tɪk/)
- (ii) all /k/ in SFWW place only were substituted by /t/ (e.g. /brek, fəst/ → /bret, fəst/)
- (iii) all /k/ in SIWW place only were substituted by /k/ (e.g. /mei, kɪŋ / → /mei, tɪŋ /)

(iv) all /k/ in SFWF place only were substituted by /t/ (e.g. /kɪk/→ /kɪt/)

(v) all /k/ in a word were substituted by /t/ (e.g. /kɪk/→ /tɪt/)

In order to keep the analysis in manageable proportions, combinations of (i)-(iv) were not implemented in the analysis.

5.2.2: Use of Computer in the Study

The task in hand involved effecting certain operations, describable in terms of phonological processes, on a data sample which represents 'common' lexical items found in children's vocabularies. The task may be summarized in a form of a diagram:

The stages 1-4 in the diagram were carried out with the aid of a computer. A Burroughs B6800 computer was used due to its availability at Leicester Polytechnic. The majority of operations were implemented by using the facility of Command and Edit Language (CANDE), which enables the manipulation of characters in a text string in certain ways (e.g. deletion or replacement of characters; see "User Guide to CANDE" by Leicester Polytechnic Computer Centre, 1982). A program however needed to be written by the Computer Centre to enable satisfactory completion of the task. These points will be pursued further below, where each operational stage, specified in the above diagram, is examined in detail.

Stage 1: The Data Sample

The data sample was stored in the computer. It consists of 1836 non-inflected lexical items. They were stored in a phonemic form with primary stress and syllable boundaries marked (e.g. bə, 'na, nə; 'bas, kIt). Before any operations were carried out on the data, it was ascertained, that no homophony inherent to the English language was present in the data file.

The main requirement for the use of CANDE is explicit and unique specification of the characters to be manipulated. In order to satisfy this requirement, certain markers needed to be attached to the lexical items. The start of the word was marked by the character '&' and the end of a word by '\$', in order to be able to distinguish the word initial and word final positions from the word

medial positions (e.g. &'kɹt\$; &'skrim\$). The word medial positions were specified with reference to the syllable boundary markers.

Stages 2 and 3: The operations carried out; The Resultant Forms Files

The operations that were carried out on the data sample involve manipulation of segments as specified by the phonological processes found in both normal and disordered child phonologies (see Appendix 3). The manner in which the computer is utilized in the implementation of the various simplifications, depends largely on the ability to specify the operations explicitly and uniquely (see section 5.2.1 above).

Two commands of CANDE were used: the find and replace commands. The find command enables one to find and display on the screen those words containing the characters specified. Whereas this is not a necessary step in obtaining FLOSS-values and IMH it is a very helpful way of ascertaining that the particular specification is indeed explicit and unique enough to enable the operations to be carried out satisfactorily. For example, the command

```
find lit "&'pr":t
```

finds all word initial /pr/-clusters with primary stress and displays them on the screen. The find command creates no new files.

The replace command enables the actual implementation of the operations on the data sample and needs to be separately and manually specified for each individual process operation. The command

```
rep lit "s" "t"
```

replaces all 's' in the input file by 't'. This produces a 'resultant forms file'. If we call the new file "Stopping/s", we can save it for further processing by typing the command

```
save as stopping/s
```

This new file then serves as an input for the program, which identifies homophonous types, forms and pairs (see Stage 4 below).

Prior to carrying out the replace command, it is possible to display the affected words (i.e. the resultant forms) on the screen by typing in the command

```
rep lit "s" "t":t
```

This command does not result in a new file. In other words, it does

not actually carry out the operations on the input file, and as such is another way of checking that the specified command has the effects required. It may be considered somewhat advantageous to the find command in that it enables the inspection of the actual forms that would be produced if the replace command applied on the data sample.

In addition to being able to carry out commands which affect every possible occurrence of specified characters in a word, it is also necessary to be able to implement operations in particular places in syllable structure. CANDE was able to cope satisfactorily only with the SIWI, SFWW and SIWW places of structure. A separate program had to be written for effecting operations in the SFWF place, the reasons for which will become apparent shortly.

For the syllable initial places in structure, the replace command needed to take into account the fact that segments in these positions may or may not have primary stress. This was achieved by using the facility of the replace command to implement more than one replacement simultaneously on the data sample. To take an example, if we wanted to replace all SIWI 'bl' by 'b', we would need to type in the following command

```
rep lit "&'bl" "&'b", lit "&bl""&b"
```

This affects words with or without primary stress in the SIWI position (e.g. /'blu/ and /blɔ, 'manʒ/).

As is clear from the above examples, the characters in the SIWI and SFWF places are accessed by reference to the markers indicating the start and end of a word. The within word places are specified in reference to the syllable boundary marker e.g. rep lit "s","t," or rep lit ",s","t". When using CANDE these specifications impose a common problem for all four places in structure. By using the appropriate markers as reference points, it is possible to access only those characters which are immediately adjacent to the specific markers. For instance, the commands

```
rep lit "&'r" "&'w", lit "&r" "&w"
```

```
rep lit ", 'l" ", 'w", lit ", l" ", w"
```

```
rep lit "k$" "$" (deletion of WF 'k')
```

would not effect the appropriate replacements in words such as /'trɪk/, /'eɔ, rə, pleɪn/ or /'nekst/. Because of lack of computing resources, it was not viable to write several programs to deal with

this problem. Therefore, certain amendments to the running of CANDE and the task in hand needed to be made.

Due to the ease of specification of the relevant SIWI consonant clusters, it was plausible to define each WI consonant cluster, which could not be specified in reference to the word initial marker and which were affected by the present operations, separately in the replace commands. That is to say, only the second and third terms in word initial clusters can be given this specification. As table 5.6 (overleaf) shows, several processes needed a separate specification of the relevant consonant clusters in the SIWI place in structure. Following Table 5.6, the replace command for the Gliding of l-w in the SIWI place would then read

```
rep  lit  "&'l'""&'w", lit  "&l'""&w", lit  "&'bl'""&'bw", lit
"&bl'""&bw", lit  "&'pl'""&'pw", lit  "&pl'""&pw", lit  "&'spl'""&'spw",
lit  "&spl'""&spw", lit  "&'sl'""&'sw", lit  "&sl'""&sw", lit
"&'kl'""&'kw", lit  "&kl'""&kw", lit  "&'gl'""&'gw", lit  "&gl'""&gw", lit
"&'fl'""&'fw", lit  "&fl'""&fw"
```

However, to overcome the problem of character specification for consonant sequences occurring in the other three places in syllable structure is somewhat less straightforward. The difficulty hinges upon two main considerations. In regard to the word medial places, the relevant consonant clusters are not easily specifiable or readily accessible. As for the word final position, the relevant clusters are too numerous for prompt and accurate manual specification. The separate specification of 108 WF consonant clusters (Gimson, 1981:246-253) in the replace commands for such profilic phonological processes as Final Consonant Deletion and WF Devoicing would indeed be too cumbersome a task.

Two separate solutions for the two problems, concerning the execution of operations in the word medial and word final places, were arrived at. Firstly, it was decided not to take into account those word medial clusters, which cannot be specified in reference to the syllable boundary markers. This decision was based on the following three arguments:

- (1) Since sequences of two intervocalic consonants are divided as -C,C-, the number of possible intervocalic clusters is reduced.
- (2) Whereas sequences of more than two intervocalic consonants

Table 5.6: The Phonological Processes Requiring Explicit Specification of Relevant Consonant Clusters in the Replace-command, when Operating in the SIWI Place in Structure

Phonological Process	SIWI Clusters Specified
Fronting k-t	sk, skr, skw, skl, skj
Gliding l-w ; Gliding l-j	pl, bl, kl, gl, fl, sl, spl
Gliding r-w ; Gliding r-j	pr, br, tr, dr, kr, dr, fr, θr, spr, str, skr
Prevocalic Voicing	sp, st, sk, sf ,spr, spl, str, skr, skw, skl, skj, spj, stj
WI Cluster Reduction	spl, spr, str, skr, skw

produce consonant clusters, they are most likely not very frequent in child vocabularies due to their complexity.

(3) It seems highly unlikely, that words containing word medial clusters result in homophony, and as such are not of crucial importance for the present study (see Section 5.3.1 below).

The two last points are indeed supported by an inspection of the data sample. As can be seen from Table 5.7 (overleaf), words containing intervocalic clusters are rare and not likely to result in homophony, when the relevant operations are carried out on them.

The solution applicable to the word medial places in structure is not feasible for dealing with the word final clusters. This is due to the large number of words in the data sample consisting of word final clusters, and to the high likelihood of homophony, when members in these clusters are either deleted or replaced by other consonants. It was therefore necessary to write a separate computer program to implement the operations in the SFWF place in structure. This program enables either replacement or deletion of specifiable characters in the SFWF positions. It is run by typing

```
r wf; file old=filename1; file new=filename2
```

where filename1=the Data Sample

filename2=name of the produced resultant file

The program consequently asks for the following information from the user:

Word final character?

Replacement character (press return to delete)?

List changed words?

Unfortunately, the program does not allow simultaneous operations as an in-built facility. Such operations can only be implemented by consecutive application of operations on the data sample.

Stages 4: Identification of Homophonous Types, Forms and Pairs

The resultant forms files created for each operation served as input to a program written by the Leicester Polytechnic Computer Centre to identify homophonous types, forms and pairs. The number of homophonous pairs equal the respective FLOSS-values for processes and process combinations (see Chapter 3), which values were then tabulated for further analysis (see Sections 5.3 and 5.4 below). The number of homophonous types and forms per process file provide the

Table 5.7: Words in the Data Sample Containing Consonant Clusters in
SFWW and/or SIWW Places in Structure

across	express	postman
aerodrome	eyebrow	postoffice
aeroplane	fireplace	surprise
airplane	goldfish	tablecloth
afraid	grandfather	umbrella
ambulance	hairdresser	undress
angry	handbag	upstairs
asleep	head-dress	
bridesmaid	hundred	
candlestik	hungry	
cauliflower	instead	
concrete	interest	
costume	lamp-post	
country	lampshade	
downstairs	lipstick	
dragonfly	milkman	
drawbridge	nightdress	
electric	pastry	
empty	photograph	
entry	playground	
excuse	postbox	

means of calculating IMH for the processes and process combinations (see Chapter 3). These calculations were not however automatized but performed by hand.

5.3. Study 1: Single phonological processes.

In Study 1 only one phonological process operates at a time on the lexical sample. For the context-dependent processes this implies that the processes operate in one place in syllable structure at a time. This in turn indicates that there is no potential for multiple homophony for those context-dependent processes which involve the substitution of a phonemic segment by another (i.e. Prevocalic Voicing and WF Devoicing) or the substitution of two phonemic segments by one segment (i.e. WI Cluster Reduction).

e.g. $/kad/ \rightarrow /kat/$ WF Devoicing 'd - t'
 $/prei/ \rightarrow /pei/$ } WI Cluster Reduction
 $/strei/ \rightarrow /stei/$ } 'pr - p'/'tr - t'

There is however potential for multiple homophony by the context-dependent processes within the process category of Final Consonant Deletion even when they operate as single processes. This potential hinges upon the presence of word final clusters which consists of the same phonemic segments in a different order. For the present data sample which consists of no inflected forms there are three pairs of English clusters which could serve as an input to a F.C.D. process and as such imply potential for multiple homophony:

ps - sp
st - ts
sk - ks

In other words, the deletion of $/p/$, $/t/$, $/k/$ and $/s/$ in the SFWF position has potential for multiple homophony in Study 1. While the potential exists in theory it is very difficult to find examples to illustrate it. On the basis of some accents of English we can arrive at the following illustration. The illustration does, however, include also an inflected form:

F.C.D

'mask' $/mæsk/ \rightarrow /mæs/$
'macks' $/mæks/ \rightarrow /mæs/$
'mass' $/mæs/ \rightarrow /mæs/$

This example illustrates an exception to the characteristic nature of single processes: usually no multiple homophony can be produced by single processes (i.e. the maximum number of identical homophonous forms is two). This does not however apply to Glottal Replacement,

which cannot produce any homophony at all if only one process within this process category operates at a time on the lexical system.

e.g. $k \rightarrow \text{ʔ}$ WF position
 $/sæk/ \rightarrow /sæ\text{ʔ}/$

There are no words of the form $/sæ\text{ʔ}/$ in an English lexical sample for the resultant form to match up with.

When the processes within the context-independent process categories, namely Stopping, Fronting and Gliding, operate in all places in syllable structure simultaneously multiple homophony can be produced. In other words this can occur when the same process (e.g. Stopping $s - t$) operates in every possible place in syllable structure (i.e. SIWI, SFWW, SIWW and SFWF, see Section 5.2.1). In order to keep this study in manageable proportions, each process is considered operative in the four different places in syllable structure separately and in all places simultaneously. In other words, not all possible combinations of the different syllable structures are considered. When a context-independent process operates in all places simultaneously, there is potential for multiple homophony. This is essentially the same situation when two processes operate in different places in syllable structure simultaneously (see Section 4.3.2). The production of multiple homophony for processes operating in all places in syllable structure simultaneously occurs when the data sample consists of at least two words upon which the process operates. This has the potential of producing a resultant form which matches with a word in the lexical sample.

e.g. Stopping $s - t$
 $/sɪs/ \rightarrow /tɪt/$
 $/sɪt/ \rightarrow /tɪt/$
 $/tɪt/ \rightarrow /tɪt/$

The maximum number of identical homophonous forms is however four, the production of which can be illustrated by the following example:

e.g. Fronting $k - t$
 $/kɪk/ \rightarrow /tɪt/$
 $/kɪt/ \rightarrow /tɪt/$
 $/tɪk/ \rightarrow /tɪt/$
 $/tɪt/ \rightarrow /tɪt/$

Multiple homophony produced by these means may not prove to be particularly extensive in an actual analysis (see Section 5.3.1, further).

5.3.1: Results

The FLOSS-values and IMH (where applicable; see Section 5.3, above) for the processes within the seven process categories investigated in Study 1 are summarized in Table 5.8, Appendix 4. The FLOSS-values reflect the number of homophonous pairs produced in the data sample where the particular processes operated one at a time. The IMH were obtained as a ratio of homophonous forms to homophonous types (see Chapter 3). To enable useful comparisons to be made between the FLOSS-values produced, they were rank ordered (Tables 5.9 and 5.10, Appendices 5 and 6). The rank ordering was done separately for the SIWI and the SFWF places in structure. As is apparent from Appendix 4, it was not informative to rank order the FLOSS-values for the context-independent processes operating in the SFWW and the SIWW places owing to the very small differences in the FLOSS-values (see further, below). The FLOSS-values produced for the context-independent processes operating in all possible positions in a word simultaneously were however rank ordered (Table 5.11, Appendix 7).

As is apparent from Table 5.8 (Appendix 4) no multiple homophony was produced by those single processes which had potential for multiple homophony. This is not particularly surprising taking into account the manner in which multiple homophony could have been produced by single processes (see Section 5.3, above). It therefore seems reasonable to conclude that multiple homophony tends not to occur when single processes operate on a lexical system.

On the basis of Tables 5.9 and 5.10 (Appendices 5 and 6), we can compare the mean FLOSS-values for the SIWI and the SFWF positions (see Table 5.12, overleaf). As Table 5.12 indicates the mean FLOSS-value was greater for the SFWF ($\bar{x} = 7.43$; $SD = 9.53$) than the mean FLOSS-value for the SIWI position ($\bar{x} = 4.67$; $SD = 4.85$). As such, the single processes operating in the SFWF position can be considered somewhat more deleterious to the functional adequacy of the phonological system than the processes operating in the SIWI position. We shall examine shortly whether there is any further differentiation in regard FLOSS-values between the different process categories operating within the two syllable positions.

Table 5.12: Mean FLOSS-values for processes operating in the SIWI or the SFWF positions: Study 1

Position	N	$\sum x$	$\bar{x}$	SD
SIWI	49	229	4.67	4.85
SFWF	40	299	7.43	9.53

Key:

- N = number of processes
- $\sum x$ = sum of FLOSS-values
- $\bar{x}$ = mean FLOSS-value
- SD = Standard Deviation

In addition to the rank ordering of FLOSS-values, Table 5.11, (Appendix 7) indicates whether the FLOSS-values produced were additive or non-additive in relation to the individual FLOSS-values produced for the process when it operates in all the places in syllable structure (ie. SIWI, SFWF, SIWW, SFWF) separately. That is to say, that a non-additive FLOSS-value indicates that new homophony resulted as a consequence of the process operating in all places in structure simultaneously. As Table 5.11 shows there was only one instance where this appeared to be the case.

It must however be noted that an additive FLOSS-value does not necessarily imply that no new homophony was produced as a result of the process operating in the different places in structure simultaneously. The presence of new homophony may be 'counter-balanced' by loss of homophony which is present when the process operates only in one place in structure at a time, but disappears when the process operates in all the places simultaneously (see Section 5.4.1, below). It appears, however, that counter-balancing may not in fact have any appreciable effect on the additive value. In order for an apparently additive FLOSS-value not to be additive, every occurrence of new homophony must be counter-balanced by disappearance of homophony. This appears to be an unlikely occurrence.

A further comparison which can be carried out on the basis of the results obtained, is to compare mean FLOSS-values for the different process categories (eg. Fronting, Stopping, etc.). This kind of comparison may prove useful in the clinical context if one wants to determine which general process categories lead to a greater FLOSS and consequently merit more urgent clinical attention. For instance, one may want first to choose a process category to work on and then address individual processes within that category (see Chapter 6, below). It is emphasized, however, that while the present study does not aim at a procedure for remedial planning, it attempts to anticipate potential uses of the results obtained. On the basis of Tables 5.9 and 5.10 mean FLOSS-values for each of the process categories were calculated. These are summarized in Tables 5.13 and

5.14 (overleaf). As Table 5.13 shows, the highest mean FLOSS-value was produced for the process category Fronting ($\bar{x}$ = 11.50; SD = 12.03) followed by Gliding ($\bar{x}$ = 7.00; SD = 5.60), Prevocalic Voicing ($\bar{x}$ = 6.00; SD = 7.85), Stopping ($\bar{x}$ = 5.10; SD = 4.23) and WI Cluster Reduction ($\bar{x}$ = 3.27; SD = 2.68). It must be recognized, however, that the mean FLOSS-value for Fronting is a reflection of the FLOSS-value of 20 which was obtained for the process $k-t$ within Fronting. The order of the mean FLOSS-values for the SFWF position (Table 5.14) was somewhat different. The highest mean FLOSS-value was obtained for Final Consonant Deletion ($\bar{x}$ = 11.00; SD = 11.44), which was followed by Fronting ($\bar{x}$ = 7.00; SD = 11.55), WF Devoicing ($\bar{x}$ = 5.00; SD = 7.09), Stopping ($\bar{x}$ = 3.70; SD = 4.85) and Gliding ($\bar{x}$ = 0). Again, it is necessary to recognise the effect of the process $k-t$ on the mean FLOSS-value of the Fronting category. Furthermore, Gliding of the non-syllabic lateral has no effect on FLOSS in the SFWF position. The potential clinical use of these results will be discussed in Chapter 6, Section 6.2 (see also Chapter 7).

Tables 5.13 and 5.14 also provide the means of comparing the mean FLOSS-values for the SIWI and SFWF positions for the process categories of context-independent processes (viz. Stopping, Fronting and Gliding). For each of the process categories a higher mean FLOSS-value was produced when the processes were operative in the SIWI position rather than the SFWF position. However, as is apparent from Tables 5.9 and 5.10 (Appendices 5 and 6), the precedence of the SIWI or the SFWF positions can vary for the individual processes within the process categories (e.g. Fronting $k-t$; SIWI:FLOSS = 20; SFWF:FLOSS = 23). This in turn may have implications for treatment planning (see Chapter 6, further).

It has already been pointed out that the context-independent processes operating in the within-word positions had only a very marginal effect on the loss of functional adequacy. This is further apparent from Table 5.15 (overleaf) which summarizes the mean FLOSS-values for the SFWW and the SIWW positions. The operation of

Table 5.13: Mean FLOSS-values for process categories: SIWI position

Process Category	N	$\sum x$	$\bar{x}$	S.D.
Stopping	10	51	5.10	4.23
Fronting	2	23	11.50	12.03
Gliding	4	28	7.00	5.60
WI CR	26	85	3.27	2.68
Prevoicing	17	42	6.00	7.85

Table 5.14: Mean FLOSS-values for process categories: SFWF position

Process Category	N	$\sum x$	$\bar{x}$	S.D.
Stopping	10	37	3.70	4.85
Fronting	3	29	7.00	11.55
Gliding	4	0	0	0
WF Devoicing	7	35	5.00	7.09
F.C.D.	18	198	11.00	11.44

Table 5.15: Mean FLOSS-values for context-independent processes operating in the SFWW and the SIWW places in structure

	N	$\sum x$	$\bar{x}$	S.D.
SFWW	15	0	0	0
SIWW	23	5	0.22	0.60

the processes in the SFWW position produced no homophony in the lexical sample. Similarly, the processes operating in the SIWW position produced a very small amount of homophony. Therefore, one can conclude that single processes operating in the within-word positions are not destructive to the functional adequacy of children's phonological systems.

Since the tables which summarize these results are largely self-explanatory there is no reason to discuss the results for the individual processes in any detail here. Further processing of the individual results would have been appropriate if we had some means of comparing the results with FLOSS-values produced for other lexical samples. Furthermore, it would have been interesting to compare the FLOSS-values with the frequency-of-occurrence of the affected lexical items in the lexical sample. In other words, it would have been interesting and clinically useful to determine whether higher frequency results in higher FLOSS-values. This would have also been appropriate in relation to Study 2. Unfortunately, it was not possible to examine any potential correlation between FLOSS and frequency-of-occurrence of the affected items. The computing system employed in the present analysis (see Section 5.2.2) did not allow the identification of the number of words upon which the processes operated. Furthermore, it would have been appropriate to compare the FLOSS-values with a published frequency account of phonemes occurring in any sample of child vocabulary. There do not however appear to be such accounts available.

This section summarized the results for the operation of processes one at the time on the lexical sample. The implications of the results for the theoretical framework developed for the assessment for the functional adequacy of children's phonological systems will be assessed in Chapter 6, Section 6.2. The relevance of the results for clinical usage will also be evaluated. The next section (ie. Section 5.4) will examine the results for Study 2, which investigated the effect of the operation of pairs of phonological processes in combinations on the functional adequacy of children's phonological systems.

5.4 STUDY 2: Combinations of two phonological processes

Study 2 reflects a situation in which combinations of two processes operate on the lexical sample. That is to say, two or more phonological contrasts are missing from the phonological system, the actual number depending on the processes entering a combination (see Section 4.3.1.4). Study 2 considers only those combinations of two processes, from the eight processes studied, which are potentially compatible with new homophony (see Section 4.3). The processes incompatible with new homophony are not included in the calculations, since their functional consequences can be largely predicted on the basis of the FLOSS-values of the corresponding single processes (i.e. Study 1). Although the FLOSS-values for some process combinations incompatible with new homophony are not simply additive (see Table 4.2, Section 4.3.1.2.3), no separate FLOSS-values are calculated for such combinations. It is reasonable to predict such FLOSS-values on the basis of the values for the respective single processes in that the alteration of process specifications is unlikely to have any considerable effect on FLOSS (see 5.4.1, below). As was pointed out in Section 4.3, it is the alteration of process specifications which can produce FLOSS-values lower than the respective additive values for combinations of two processes incompatible with new homophony.

All possible combinations of two processes generated on the basis of the eight processes which operate in the same place in syllable structure were studied. The combinations of processes were allocated into different process relationships viz. Complete Feeding, Incomplete Feeding, Conspiring relationships (see Section 4.3 and below). Only the SIWI and the SFWF places of syllable structure were considered. On the basis of the results in Study 1, it was decided that the processes operating in the within word places of structure are not likely to have appreciable detrimental effect on the functional adequacy of children's phonological systems. It is difficult to envisage any appreciable change in the effect of the within word positions on FLOSS when two processes operate in a combination rather than when only one process operates. This assumption was indeed supported by a trial analysis which was carried out for the operation of the processes entering a Complete Feeding relationship in the SIWW place in structure. The results of

this trial analysis are summarized in Table 5.16 below.

Table 5.16: FLOSS-values and IMH for processes entering a Complete Feeding relationship in the SIWW place in structure

Processes	FLOSS-value	IMH
k-t;t-d	2	2:1
k-g;g-d	0	-
f-p;p-b	2	2:1
f-v;v-b	1	2:1
θ-t;t-d	2	2:1
θ-ð;ð-d	0	-
s-t;t-d	2	2:1
s-z;z-d	2	2:1
ʃ-t;t-d	2	2:1
ʰt;t-d	2	2:1
tʃ-dʒ;dʒ-d	0	-

As is apparent from Table 5.16, the production of homophony by these process combinations in the SIWW place in structure was limited. Table 5.16 also shows that no multiple homophony was produced.

It was not feasible (see Section 5.2.2) to investigate all the possible combinations of two processes which can operate in a different place in syllable structure. Therefore, it was decided to examine a selection of processes operating simultaneously in the SIWI and the SFWF places of structure only. As with the processes operating in the same place in syllable structure, it was considered reasonable to exempt the within-word places from consideration. On the basis of the results obtained for the single processes in Study 1 three processes carrying the highest and the lowest FLOSS-values for the context-independent and the context-dependent processes in the two places in syllable structure were examined. More specifically, the FLOSS-values for these combinations of processes were obtained for every possible combination of the

context-independent and the context-dependent process groups and the places in syllable structure.

viz.

- (1) SIWI: context-independent
 SFWF: context-independent
- (2) SIWI: context-independent
 SFWF: context-dependent
- (3) SIWI: context-dependent
 SFWF: context-independent
- (4) SIWI: context-dependent
 SFWF: context-dependent

Within these groups every combination of the high and low FLOSS-values were considered (viz. high-high; high-low; low-high; low-low) totalling up to 36 operations per group. For the two groups with the context-dependent processes operating in the SFWF place in structure the processes involving a substitution or a deletion process were considered separately, increasing the total number of operations that were carried out for these groups to 72 per group. The actual processes selected for this part of the study on the basis of the results of Study 1 are summarized below:

- (1) SIWI: context-independent
 - three processes with the highest FLOSS-values
 - Fronting k-t
 - Gliding l-w
 - Stopping f-p
 - three processes with the lowest FLOSS-values
 - Stopping z-d
 - Gliding r-j
 - Stopping v-b
- (2) SFWF: context-independent
 - three processes with the highest FLOSS-values
 - Fronting k-t
 - Stopping s-t
 - Stopping tʃ-t
 - three processes with the lowest FLOSS-values
 - Fronting ɲ-n
 - Stopping ʃ-d
 - Gliding l-j

(3) SIWI: context-dependent

- three processes with the highest FLOSS-values

Cl. Reduction st-t

Cl. Reduction tr-t

Cl. Reduction dr-d

- three processes with the lowest FLOSS-values

Cl. Reduction pr-p

Cl. Reduction θr-θ

Cl. Reduction spl-p

(4) SFWF: context-dependent

(A) Substitution processes

- three processes with the highest FLOSS-values

WF Devoicing d-t

WF Devoicing g-k

WF Devoicing z-s

- three processes with the lowest FLOSS-values

WF Devoicing dʒ-tʃ

WF Devoicing ʃ-θ

WF Devoicing b-p

(B) Deletion processes

- three processes with the highest FLOSS-values

F.C.D. t-0

F.C.D. n-0

F.C.D. k-0

- three processes with the lowest FLOSS-values

F.C.D. b-0

F.C.D. ʃ-0

F.C.D. ʃ-0

The selection of the processes with the lowest FLOSS-values for some of these groups involved a choice from more than three processes, since there were several processes with a FLOSS-value of 0. In such instances the selection was made on the basis of a 'variety' principle so that maximally differing processes were included in this part of the study. For instance, in regard the context-dependent processes operating in the SIWI position both two-term and three-term clusters were included and of the two-term clusters representatives of the plosive and fricative sound classes were selected. This operating principle was intended to provide a

representative set of results showing the effect of such combinations of processes on the functional adequacy of children's incomplete phonological systems.

The assignment of the eight processes into different process relationships was based on the definitions outlined in Chapter 4. In fact, the theoretical framework was developed on the basis of the possible combinations into which the processes studied could enter into. All the possible process relationships for the eight processes were worked out for the calculation of FLOSS-values and IMH. While this was for most part a straightforward exercise, certain observations need to be made in regard to some of the relationships.

First of all, a decision was made to consider only Incomplete Feeding (Condition A) relationships even though it is recognized (see Section 4.3.1.2.2) that for some of the relationships the production of homophony by Condition B is potentially different from Condition A relationships. It would appear that this potential difference would be difficult to realize, since the difference is totally dependent on the operation of the processes in clusters.

e.g. Type3IF/Condition A (SIWI)

Process 1: sp - p

spl - pl

Process 2: l - j

pl - pj (ex. spl - spj)

Type3IF/Condition B (SIWI)

Process 1: l - j

spl - spj

Process 2: sp - p

spj - pj (ex. spl - pl)

As such it is envisaged that the FLOSS-values and IMH for processes entering an Incomplete Feeding relationship (Condition A) provide an indication of these values for the same processes operating in Condition B. Furthermore, the relevance of the Incomplete Feeding relationships in the actual assessment of the functional adequacy of children's phonological systems (see Chapter 6) is somewhat doubtful, thus justifying the restriction imposed upon the calculation of FLOSS-values and IMH. This restriction also contributes towards keeping this study in manageable proportions.

Another point which needs to be noted here concerns the identical potential for homophony when two processes enter a Complete Feeding relationship and a Conspiring relationship. As was shown in Section 4.3.1.2.1, when the second process in a Complete Feeding relationship belongs to either the process category of Final Consonant Deletion or Glottal Replacement, the functional consequences of the operation of these processes are identical to the Conspiring of both of the processes to zero or a glottal stop.

$$\begin{array}{l} \text{e.g. Process 1: } t\int - t \\ \qquad \qquad \qquad \downarrow \\ \text{Process 2: } \qquad \qquad t - 0 \end{array} \Bigg\} = \left\{ \begin{array}{l} t\int - 0 \\ t - 0 \end{array} \right.$$

$$\begin{array}{l} \text{Process 1: } \int - d \\ \qquad \qquad \qquad \downarrow \\ \text{Process 2: } \qquad \qquad d - \int \end{array} \Bigg\} = \left\{ \begin{array}{l} \int - \int \\ d - \int \end{array} \right.$$

In the overall ranking of the FLOSS-values and IMH separate entries representing such Complete Feeding and Conspiring processes are recorded in the rank tables (see Section 5.4.1).

It should also be pointed out that only those process specifications which have potential for homophony are deemed to have been altered (see Section 4.3.1.2). Furthermore, in regard to the SFWF position, only those altered process specifications which are 'non-inflectional' have the potential for homophony. Thus, the process specifications for the following two processes when they operate in a combination are not deemed altered, since the process specification for Process 2 consists of a consonant cluster evidenced only as an inflection.

$$\begin{array}{l} \text{e.g. Process 1: } t - 0 \quad (\text{ex. } t\int t - t\int) \\ \text{Process 2: } t\int - 0 \quad (\text{ex. } t\int t - t) \end{array}$$

5.4.1 Results

The FLOSS-values and the IMH obtained for the combinations of two processes studied are summarized in Appendix 8. The FLOSS-values reflect the raw scores of the number of homophonous pairs produced and the IMH are obtained as a ratio of homophonous types to homophonous forms (see Chapter 3). The numerical results will be analysed further by using descriptive statistics (e.g. Woods, Fletcher and Hughes, 1986). The present study does not lend itself

to inferencing about the probability of the production of the same numerical values for other lexical samples (see Chapter 3). The values produced more than likely differ for samples consisting of different lexical items as the production of homophony is dependent on the specific lexical items in a sample. The question of whether the results can be assumed to reflect the functional inadequacies of incomplete phonological systems of all children of particular age groups should be addressed in relation of the representativeness of the lexical sample serving as a data sample. In relation to the present data sample these issues were discussed in Chapter 3 and Section 5.1.

The analysis of the results are presented in two formats. Firstly, the FLOSS-values and IMH are rank ordered for all the combinations of processes studied. This is done separately for two different places of syllable structure (i.e. SIWI and SFWF). Secondly, on the basis of these results some of the theoretical hypotheses about the different process relationships and their relationships to functional adequacy (see Section 4.3) will be examined. More specifically, we can examine whether

- (i) certain process relationships realize their theoretically greater potential for FLOSS and multiple homophony in relation to other process relationships
- (ii) the alteration of process specifications has any effect on the FLOSS of the phonological system
- (iii) there is actual differentiation in the FLOSS and incidence of multiple homophony for the different types of Incomplete Feeding relationships
- (iv) the FLOSS-values and IMH correlate with one another.

Investigation of these issues will be partly selective in order to keep the study in manageable proportions (see below).

The rank ordering of FLOSS-values and IMH for all combinations of two processes operating in the SIWI and the SFWF places in structure are shown in Tables 5.17 - 5.20 in Appendices 9 - 12. The rank ordering of FLOSS-values and IMH for the combinations of two processes operating in different places in syllable structure are shown in Tables 5.21 and 5.22 in Appendices 13 and 14. We shall examine Tables 5.17 - 5.20 first. We can carry out several comparisons on the basis of mean FLOSS-values and mean IMH.

As Table 5.23 (overleaf) shows the mean FLOSS-value of 22.54 (SD=19.84) was produced for the processes operative in the SFWF position as compared to the mean FLOSS-value of 16.02 (SD=10.63) for the SIWI position. This indicates a tendency for a greater FLOSS in a phonological system when a combination of two processes potentially compatible with new homophony operate in the SFWF place rather than in the SIWI place.

Only the IMH which indicate the presence of multiple homophony (i.e. IMH > 2:1) are ranked in Tables 5.19 and 5.20. Those IMH indicating absence of multiple homophony are summarized in Appendix 8, which contains all the results. On the basis of these results a mean IMH for all processes operating in the SIWI or the SFWF position was calculated (Table 5.24, overleaf). The process combinations involving glottal replacement were excluded from Table 5.24 since they do not have any potential for multiple homophony (see Section 4.3.1.3). As Table 5.24 shows, a slightly higher mean value 2.05 (SD=0.08) was obtained for the processes operating in the SIWI position as compared to the value of 2.02 (SD=0.05) for the SFWF position. This indicates a slightly greater tendency for multiple homophony resulting from the combination of two processes potentially compatible with new homophony operating in the SIWI position by comparison with process combinations operating in the SFWF position. Furthermore, as Table 5.25 (overleaf) shows, of the multiple homophony produced, the mean IMH is higher for the processes operating in the SIWI position ($\bar{x}$ =2.14 ; SD=0.08) than for the processes operating in the SFWF position ($\bar{x}$ =2.07 ; SD=0.06). The greater tendency of the processes operating in the SIWI place for multiple homophony in the present study is further evident from Table 5.26 (overleaf) which shows that the proportion of process combinations with multiple homophony is greater for the SIWI position (38%) as compared to the SFWF position (29%).

Comparison of the information given in Table 5.23 with that given in Tables 5.24 - 5.26 reveals that the tendency for high FLOSS does not necessarily entail a tendency for high IMH in the present study. The higher mean FLOSS for the SFWF position is probably a reflection of the large number of process combinations conspiring to zero (see Table 5.18, Appendix 10). As was apparent from Study 1 the processes operating within the process category Final Consonant

Table 5.23: Mean FLOSS-values for all process combinations operating in the SIWI or the SFWF position

Position	N	$\sum x$	$\bar{x}$	SD
SIWI	175	2803	16.02	10.63
SFWF	269	6063	22.54	19.84

Table 5.24: Mean IMH (inclusive of IMH of 2:1) for all process combinations operating in the SIWI or the SFWF position

Position	N	$\sum x$	$\bar{x}$	SD
SIWI	175	359.25	2.05	0.08
SFWF	211	426.6	2.02	0.05

Table 5.25: Mean IMH for all process combinations producing homophony (exclusive of IMH of 2:1) in the SIWI or SFWF positions

Position	N	$\sum x$	$\bar{x}$	SD
SIWI	67	143.25	2.14	0.08
SFWF	62	128.60	2.07	0.06

Table 5.26: Incidence of multiple homophony for all process combinations operating in the SIWI or the SFWF positions

Position	no. of process combinations with multiple homophony	total no of process combinations	%
SIWI	67	175	38
SFWF	62	211	29

Deletion (see Table 5.8; Appendix 4) produced the highest FLOSS-values for single processes. Therefore, relatively high FLOSS-values could result from combinations of such processes without the occurrence of multiple homophony. This does not however necessarily mean that no multiple homophony or new homophony was produced by these combinations of processes but simply suggests that the observed tendency of the 'deletion' processes for relatively high FLOSS may have had an effect on the mean FLOSS-value for the processes operating in the SFWF position.

The degree of interdependency between FLOSS and IMH can be further examined in relation to the rank ordering of the results for the two places in syllable structure separately. In this regard it was necessary to investigate whether the rank orderings of the FLOSS-values and IMH for each of the process combinations correlate. It should be noted that those combinations of processes which had no potential for multiple homophony were excluded from consideration (viz. process combinations involving glottal replacement; SFWF position), as were process combinations with FLOSS-value of zero, since they could not have any value for IMH. To investigate for a possible correlation between the two variables Spearman's rank order correlation coefficient was obtained. Calculation of the Spearman's correlation coefficient gave coefficient values of 0.57 for the SIWI position and the value of 0.59 for the SFWF position. These co-efficients are significant at the level of 0.001. While this indicates a highly significant correlation it must be recognized that the actual correlations are relatively low and are most likely affected by the relatively large samples. Nevertheless, it can be concluded that the FLOSS-values and IMH obtained in the present study are interdependent. In other words, a high or low FLOSS-value implies a high or low IMH. This adds another dimension to the assessment of functional adequacy by enabling one to make predictions about potential functional consequences of restricted phonological systems (see Chapter 6).

The results for the process combinations operating in different places in syllable structure (SIWI and SFWF) are rank ordered in Tables 5.21 and 5.22 (Appendices 13 and 14). These results are not directly comparable with the FLOSS-values and IMH produced for the

processes operating in the same place in syllable structure in that only a small selection of possible process combinations were studied in the different place in syllable structure (see above). There are however several interesting comparisons which emerge from examining the processes operating in the different place in syllable structure. First of all, it is possible to examine the presence of any tendencies in the FLOSS-values and IMH for the different combinations of processes in relation to their independent FLOSS-values (i.e. FLOSS-values for the single processes in Study 1). The mean FLOSS-values for the different combinations of high and low values are summarized in Table 5.27 (overleaf). As Table 5.27 shows, the highest mean value ($\bar{x}=32.35$; $SD=12.75$) was produced for the operation of two processes which both produced high independent FLOSS-values. This was followed by the mean values of 19.24 ($SD=10.18$) for the operation of two processes with a low independent FLOSS-value in the SIWI position and a high independent FLOSS-value in the SFWF position and of 12.33 ($SD=4.79$) for the operation of two processes with a high independent FLOSS-value in the SIWI position and a low independent FLOSS-value in the SFWF position. The mean FLOSS-value ($\bar{x}=0.94$; $SD=1.24$) was appreciably lower than the other mean FLOSS-values for the operation of two processes with low independent FLOSS-values in both syllable positions.

These observations are indicative of an interdependency of the independent FLOSS-values and the mean FLOSS-values for two processes operating in the different places in syllable structure in the present study. In other words, the simultaneous operation of two processes on a word in the SIWI and the SFWF places or on two words on a different place in syllable structure did not override the capacity for FLOSS of the two processes operating as single processes. As such, it would appear that the FLOSS-values for combinations of two processes operating in a different place in syllable structure can be predicted on the basis of the FLOSS-values for the corresponding single processes (i.e. independent FLOSS-values) when ready calculated FLOSS-values are not available for combinations of processes (see Chapter 6).

Table 5.27 also shows a larger mean FLOSS-value for those combinations of two processes which consist of a LOW (SIWI)/HIGH (SFWF) independent FLOSS-values than those combinations of processes

Table 5.27: Mean FLOSS-values for combinations of processes operating in the SIWI and SFWF positions simultaneously as a function of the production of HIGH or LOW independent FLOSS-values (i.e. in Study 1)

SIWI	SFWF	N	Σx	$\bar{x}$	SD
HIGH	HIGH	54	1747	32.35	12.75
HIGH	LOW	54	666	12.33	4.79
LOW	HIGH	54	1039	19.24	10.18
LOW	LOW	54	51	0.94	1.24

which consist of HIGH (SIWI)/LOW (SFWF) independent FLOSS-values. In light of the above observation (i.e. about the relative lack of an effect of the processes with low independent FLOSS-values on FLOSS when operating in combinations in different places in syllable structure) this indicates a greater tendency for FLOSS of the processes operating in the SFWF place rather than the SIWI place. This tendency has already been observed in Study 1 (see Section 5.3.1). It can be further shown that it is the deletion processes (i.e. F.C.D.) which are most prolific as regards FLOSS within the process combinations operating in a different place in structure with high independent FLOSS-values operating in the SFWF position. As Table 5.28 (overleaf) shows there is a difference in mean FLOSS-values for deletion and substitution processes operating in the SFWF position. This difference is most likely attributable to the properties of deletion and substitution since the mean FLOSS-values reflect the same processes operating in the SIWI place for the two types of combinations of processes.

It must be recognized at this point that it is not possible, using the present analytical techniques, to determine the extent to which the different processes in the combinations contribute to the FLOSS-values produced when operating in different places in syllable structure. Consequently, we do not know whether new homophony is produced via the operation of the two processes in a combination. The comparison of the FLOSS-values with the corresponding additive FLOSS-values (i.e. additive independent FLOSS-values from Study 1) would not necessarily reveal whether new homophony was produced. Homophony which was produced when the two processes operated as single processes may disappear when the two processes enter a combination at different places in structure. However, it seems likely that the occurrence of additive FLOSS-values could be a reasonable indicator of the absence of new homophony. The circumstances in which additive FLOSS-values could reflect the presence of new homophony are most likely relatively infrequent. For such a circumstance to occur, what is required is the operation of the processes to produce instances in which less homophony than the additive FLOSS-value for the two processes is produced, and these instances of 'lost homophony' must be counter-balanced by instances of new homophony. This situation can

Table 5.28: Mean FLOSS-values differentiated for combinations of two processes which consist of a HIGH independent FLOSS-value in the SFWF position on the basis of a Deletion or a Substitution process operating in the SFWF position

SIWI	SFWF	D E L E T I O N				S U B S T I T U T I O N			
		N	$\sum x$	$\bar{x}$	SD	N	$\sum x$	$\bar{x}$	SD
HIGH	HIGH	19	855	45.00	8.01	35	880	25.14	9.07
LOW	HIGH	17	522	30.71	5.27	37	517	13.97	7.05

be illustrated by the following hypothetical example.

e.g. SIWI: k - t and SFWF: tʃ - t

(1):

- SFWF: tʃ - t operates independently (as a single process)

$$\left. \begin{array}{l} /kætʃ/ \rightarrow /kæt/ \\ /kæt/ \rightarrow /kæt/ \end{array} \right\} \begin{array}{l} 1 \text{ homophonous} \\ \text{pair} \end{array}$$

- SIWI: k - t operates independently (as a single process)

$$/kætʃ/ \rightarrow /tætʃ/$$

- SIWI: k - t; SFWF: tʃ - t operate in a combination

$$/kætʃ/ \rightarrow /tæt/$$

One homophonous pair is lost owing to the combination.

(2):

- SFWF: tʃ - t operates independently (as a single process)

$$/tætʃ/ \rightarrow /tæt/$$

- SIWI: k - t

$$/kæt/ \rightarrow /tæt/$$

- SIWI: k - t; SFWF: t - t operate in a combination

$$\left. \begin{array}{l} /tætʃ/ \rightarrow /tæt/ \\ /kæt/ \rightarrow /tæt/ \end{array} \right\} \begin{array}{l} 1 \text{ homophonous} \\ \text{pair} \end{array}$$

If the kind of 'counter-balancing' exemplified above occurs, then the additive FLOSS-values are not in fact 'additive' in that new homophony is produced, but it is 'counter-balanced'. The point is however that it appears unlikely that such exact counter-balancing (i.e. one homophonous pair lost vs. one gained) occurs in the analysis of real data, but rather homophonous pairs may be lost or gained without being exactly counter-balanced. Therefore, in the absence of exact counter-balancing the FLOSS-values reflecting the presence of new homophony for the operation of two processes in a combination are likely to be higher or lower than the corresponding additive FLOSS-value.

On the basis of the above argument it can be assumed that the additive FLOSS-values produced for the processes operating in a different place in syllable structure in the present study are indicative of the presence of no new homophony. That is to say that the potential compatibility of the process combinations with new homophony is not actualized. Table 5.29 (overleaf) summarizes the proportion of non-additive FLOSS-values produced for all the

Table 5.29: The proportion of non-additive FLOSS-values for combinations of processes operating in a different place in syllable structure simultaneously

No. of non-additive FLOSS-values	Total incidence of FLOSS-values	%
47	216	22

Table 5.30: The proportion of non-additive FLOSS-values as a function of the production of HIGH or LOW independent FLOSS-values

SIWI	SFWF	No. of additive Floss-values	Total incidence of FLOSS-values	%
HIGH	HIGH	35	54	65
HIGH	LOW	4	54	7
LOW	HIGH	7	54	13
LOW	LOW	1	54	2

processes operating in a different place in syllable structure which were studied. As is apparent from Table 5.29, only 22% of all the FLOSS-values were non-additive. Conversely, 78% were additive, reflecting a likely lack of actual compatibility with new homophony. Furthermore, as Table 5.30 (p. 164) indicates, the highest amount of new homophony (65%) was produced by the operation of two processes with HIGH independent FLOSS-values, followed by the operation of processes with LOW (SIWI)/HIGH (SF WF) (13%), HIGH (SIWI)/LOW (SF WF) (7%) and LOW (SIWI)/LOW (SF WF) (2%) independent FLOSS-values. This order correlates perfectly with the order for the mean FLOSS-values (see Table 5.27) and is therefore indicative of the importance of new homophony for the FLOSS of a phonological system.

The observation concerning the high incidence of non-additive FLOSS-values on the one hand and the relative correlation of independent FLOSS-values and the FLOSS-values produced for the combinations of processes on the other hand appear somewhat contradictory. How can it be that while new homophony is produced, the independent FLOSS-values correlate with the FLOSS-values of combined processes? The explanation is that it appears that not enough new homophony is produced by the fact that two processes operate in a combination to override the influence of the independent FLOSS-values.

On the basis of the results in Appendix 8, a mean IMH for all processes operating in a different place in a syllable structure was calculated. A mean IMH of 2.01 (SD=0.02) was obtained reflecting the low proportion of multiple homophony produced. Only 12% of all the possible process combinations produced multiple homophony. The mean IMH for the multiple homophony produced was 2.05 (SD=0.03). 46% of the combinations of processes of the type with HIGH (SIWI)/HIGH (SF WF) independent FLOSS-values produced multiple homophony.

There is an apparent conflict between the low production of multiple homophony and the high incidence of non-additive FLOSS-values for the process combinations operating in a different place in syllable structure. This conflict is however resolved by the fact that the incidence of new homophony can be evidenced by two homophonous types corresponding to one homophonous form.

e.g.

SIWI: r - j; SFWF: t - 0

/rest/ → jest → /jes/

/jes/ → /jes/

/rut/ → ru → /ju/

/ju/ → /ju/

Investigation of potential interdependence between FLOSS and IMH for processes operating in different places in syllable structure does not necessitate the statistical analysis of Spearman's rank order correlation. It is apparent from the discussion thus far that there is a strong correlation between FLOSS and IMH for those process combinations which have a high independent FLOSS-value both in the SIWI and the SFWF positions. On the other hand, there is no correlation between FLOSS and IMH for the other types of process combinations. These findings lead to the conclusion that the process combinations operating in the SIWI and the SFWF places in structure simultaneously and which have high independent FLOSS-values are potentially more detrimental to the functional adequacy of a child's phonological system as compared to other process combinations operating in these two places in structure. Furthermore, for such combinations, a high independent FLOSS-value tends to imply the presence of multiple homophony.

The hypothesis about the potential differential relationships holding between the different process relationships in regard to FLOSS and multiple homophony can be examined in relation to the results produced. As was shown in Chapter 4 (see especially Tables 4.3 and 4.4 Section 4.3.1.2.3), a number of predictions can be made about potential differential effects of the process relationships. It should be noted however, that some of these predictions are not examined in the present study. Specifically, those predictions involving relationships which are incompatible with new homophony (see Section 4.3.1.2.3) since only those combinations of processes which were potentially compatible with new homophony were subjected to the analysis. Also, it has been considered inappropriate to investigate those hypotheses for which there are only very few instances of the respective process relationships available for investigation. Therefore, the following examination of the hypothesis made in Chapter 4 is not exhaustive.

With the above provisos, some comparisons between different process relationships can be made. The comparisons will be made on the basis of the results obtained for the different process relationships (Appendix 8 and Tables 5.17 - 5.22; Appendices 9 - 14).

These comparisons will be based on mean FLOSS-values and IMH which are calculated for the different process relationships. These have been calculated for the SIWI and SFWF places separately. Tables 5.31 and 5.32 (overleaf) summarize these mean values. As Table 5.31 shows the highest mean FLOSS-value ($\bar{x}=19.00$; $SD=11.34$) in the SIWI position was obtained for processes entering an Incomplete Feeding relationship. This was followed by the mean FLOSS-value of 17.83 ($SD=10.56$) for processes entering a Complete Feeding relationship and 11.94 ($SD=8.95$) for Conspiring processes. The order of mean FLOSS-values for the processes operating in the SFWF position was somewhat different. The highest mean FLOSS-value was produced for processes entering a Complete Feeding relationship ($\bar{x}=23.35$; $SD=21.89$), followed by Conspiring processes ($\bar{x}=21.71$; $SD=19.69$) and processes entering an Incomplete Feeding relationship ($\bar{x}=16.16$; $SD=29.21$).

Comparison of the SIWI and the SFWF positions shows that the mean FLOSS-values in the SFWF position were higher for the Complete Feeding and the Conspiring relationships than in the SIWI position but lower for Incomplete Feeding relationships. The general tendency in the present study has been for greater functional loss when processes operate in the SFWF position as compared to the SIWI position. The reversed tendency of the processes entering an Incomplete Feeding relationship may be a reflection of the small number of process combinations entering an Incomplete Feeding relationship in the SFWF position (see Appendix 10).

As Table 5.32 indicates the mean IMH for processes entering an Incomplete Feeding relationship is higher for both the SIWI ($\bar{x}=2.06$; $SD=0.10$) and the SFWF positions ($\bar{x}=2.03$; $SD=0.05$) as compared to processes entering a Complete Feeding relationship (SIWI: $\bar{x}=2.05$; $SD=0.07$; SFWF: $\bar{x}=2.02$; $SD=0.05$). The mean IMH in Table 5.32 are inclusive of all the IMH produced for the particular process relationships (i.e. also IMH of 2:1 included). As such, Table 5.32 can be viewed as reflecting the average multiple homophony produced

Table 5.31: Mean FLOSS-values for process relationships in the SIWI and the SFWF positions

Process Relationship	S N	I $\sum x$	W $\bar{x}$	I SD	S N	F $\sum x$	W $\bar{x}$	F SD
Complete Feeding	41	731	17.83	10.56	44	1023	23.25	21.89
Incomplete Feeding	49	931	19.00	11.34	14	409	16.16	29.21
Conspiring	66	790	11.97	8.92	203	4408	21.71	19.69

Table 5.32: Mean IMH (inclusive of IMH of 2:1) for process relationships in the SIWI and the SFWF positions

Process Relationships	S N	I $\sum x$	W $\bar{x}$	I SD	S N	F $\sum x$	W $\bar{x}$	F SD
Complete Feeding	41	83.96	2.05	0.07	44	88.79	2.02	0.04
Incomplete Feeding	49	100.7	2.06	0.10	14	28.45	2.03	0.05
Conspiring	66	134.98	2.05	0.08	176	355.32	2.02	0.05

by processes entering a particular process relationship. The proportion of multiple homophony for the different relationships is summarized in Table 5.33 (overleaf). As Table 5.33 indicates, the greatest potential for the occurrence of multiple homophony in the SIWI position was carried by processes entering a Complete Feeding relationship (44%), followed by Conspiring processes (33%) and processes entering an Incomplete Feeding relationship (31%), when the processes operated in the SIWI position. In the SFWF position, however, the greatest potential for the occurrence of multiple homophony was carried by processes entering an Incomplete Feeding relationship (64%), followed by processes entering a Complete Feeding relationship (27%) and Conspiring processes (26%). Furthermore, of the multiple homophony produced, processes entering an Incomplete Feeding relationship produced the highest mean IMH for both the SIWI ($\bar{x}=2.18$; $SD=0.10$) and the SFWF ($\bar{x}=2.09$; $SD=0.04$) positions. This is shown in Table 5.34 (p.168). As Table 5.34 also indicates, the second highest mean IMH in the SIWI position was produced by Conspiring processes ($\bar{x}=2.14$; $SD=0.08$) followed by the mean IMH of 2.11 ($SD=0.05$) for the processes entering a Complete Feeding relationship. In the SFWF position there is no differentiation in the mean IMH for the processes entering a Complete Feeding relationship or Conspiring processes ($\bar{x}=2.07$).

On the basis of Tables 5.31 and 5.32 we can now examine whether the theoretical tendencies postulated in Chapter 4 are realized by the present data sample. The following four hypotheses will be examined:

- (i) Processes entering an Incomplete Feeding relationship consisting of a Conspiring relationships (i.e. IF/Unaltered PS and Type 1IF) have potential for higher FLOSS than processes entering a Conspiring relationship proper.
- (ii) Processes entering an Incomplete Feeding relationship consisting of a Conspiring relationship have potential for higher FLOSS than processes entering a Complete Feeding relationship.
- (iii) Processes entering an Incomplete Feeding relationship consisting of a Conspiring relationship have potential for more multiple homophony than processes entering a Conspiring relationship proper.
- (iv) Processes entering an Incomplete Feeding relationship

Table 5.33: Proportion of multiple homophony for process relationships in the SIWI and the SFWF position (inclusive of IMH of 2:1)

Process Relationship	S N	I %	W %	I	S N	F %	W %	F
Complete Feeding	41		44		44		27	
Incomplete Feeding	49		31		14		64	
Conspiring	66		33		176		26	

Table 5.34: Mean IMH (exclusive of IMH of 2:1) for process relationships

Process Relationship	S N	I Σx	W $\bar{x}$	I SD	S N	F Σx	W $\bar{x}$	F SD
Complete Feeding	18	37.95	2.11	0.05	12	24.79	2.07	0.04
Incomplete Feeding	15	32.70	2.18	0.10	5	10.45	2.09	0.04
Conspiring	22	46.98	2.14	0.08	46	95.32	2.07	0.07

consisting of a Conspiring relationship have potential for more multiple homophony than processes entering a Complete Feeding relationship proper.

While Tables 5.31 and 5.32 illuminate the above hypotheses they do not provide conclusive evidence for or against them (see further below).

Tables 5.31 and 5.32 are based on all types of Incomplete Feeding relationships, while the above hypotheses concern only those relationships which consist of a Conspiring relationship. Mean FLOSS-values are summarized for these Incomplete Feeding relationships in Table 5.35 (overleaf). From Tables 5.31 and 5.35 it can be seen that in the SIWI position the mean FLOSS-value for processes entering an Incomplete Feeding relationship consisting of a conspiring relationship ($\bar{x}=22.89$; $SD=14.01$) is higher than the mean FLOSS-values for the processes entering Complete Feeding ($\bar{x}=17.83$; $SD=10.56$) and Conspiring relationships ($\bar{x}=11.97$; $SD=8.92$). It is not appropriate to carry out these comparisons in the SFWF position since there is only one instance of the relevant types of Incomplete Feeding in this position.

The question is now whether the observed differences in the mean FLOSS-values for the different process relationships predicted by the theoretical hypotheses are in fact attributable to the theoretical motivations which were assumed to underlie the differences. More specifically, does the higher mean FLOSS-value for the processes entering an Incomplete Feeding relationship in comparison to a Complete Feeding relationship result from the postulate that an Incomplete Feeding relationships consist of both a feeding and a conspiring relationships while a Complete Feeding relationship consists of only a feeding relationship? Similarly, does the difference in the mean FLOSS-value between the processes entering an Incomplete Feeding relationships and Conspiring relationships result from the theoretical assumption based on the fact that an Incomplete Feeding relationship consists of a feeding and a Conspiring relationship while a Conspiring relationship proper consists of only a conspiring relationship? It is unfortunately not possible to give any definitive answers to these questions within the present analysis. There are, however, some ways of examining these issues further.

Table 5.35: Mean FLOSS-values for Incomplete Feeding relationships consisting of a Conspiring relationship

Process	S	I	W	I	S	F	W	F
Relationship	N	$\sum x$	$\bar{x}$	SD	N	$\sum x$	$\bar{x}$	SD
IF Unaltered	18	412	22.89	14.01	1	27	27.00	0
PS and Type1IF								

In regard to the observed difference between the Incomplete Feeding and Conspiring relationships, it is possible to examine whether the feeding interaction may have had an effect by comparing mean FLOSS-values for the respective Incomplete Feeding relationships (i.e. IF/Unaltered PS and Type1IF) and their corresponding counter feeding relationships. If the counter feeding relationships produce mean FLOSS-values that are lower than the mean FLOSS-values for the corresponding Incomplete Feeding relationships we know that the feeding interaction has produced some instances of new homophony. If, on the other hand, the feeding interaction had no effect then the Incomplete Feeding relationships and the corresponding counter feeding relationships would produce identical FLOSS-values, since the effect of the conspiring relationship is the same for the two ordering relationships. As Table 5.36 (overleaf) shows, the mean FLOSS-values for the IF/Unaltered PS and Type1IF relationships are indeed higher than the mean FLOSS-values for the corresponding counter feeding relationships. This in turn indicates that the Incomplete Feeding interaction could have had an effect on the higher mean FLOSS-values for the Incomplete Feeding relationships in comparison with the Conspiring relationships proper. There is no way in the present study of establishing with any certainty whether the observed differences are definitely due to the Incomplete Feeding interaction.

Table 5.36 does, however, lend some support to the hypothesis that the respective counter feeding relationships in comparison with the corresponding Incomplete Feeding relationships have potential for less homophony owing to the absence of the feeding interaction, even though both of the relationships are potentially compatible with new homophony.

It was also maintained above that processes entering an Incomplete Feeding relationship have more potential for multiple homophony than the processes entering a Complete Feeding or a Conspiring relationship owing to the simultaneous presence of both a feeding and a conspiring relationship. Since the mean IMH for Incomplete Feeding in Table 5.32 reflect all types of Incomplete Feeding relationships, it is again necessary to recalculate the mean IHM to reflect only IF/Unaltered PS and Type1IF relationships. This is done only for the SIWI position. Table 5.37 (overleaf) summarizes

Table 5.36: Mean FLOSS-values for IF/Unaltered PS, counter feeding to IF/Unaltered PS, Type1IF and counter feeding to Type1IF: SIWI position

Process Relationship	N	$\sum x$	$\overline{x}$	SD
IF/Unaltered PS	12	342	28.50	12.96
co-feed IF/ Unaltered PS	12	250	20.83	9.82
Type1IF	6	70	11.67	8.43
co-feed Type1IF	6	56	9.33	5.50

Table 5.37: Mean IMH for Incomplete Feeding relationships consisting of a Conspiring relationship: SIWI position

	N	$\sum x$	$\bar{x}$	SD
(i) inclusive of IMH of 2:1	24	50.45	2.10	0.12
(ii) exclusive of IMH of 2:1	12	26.45	2.20	0.10

these mean IMH. Comparison of Table 5.37 with Tables 5.32 and 5.35 shows that the processes entering an Incomplete Feeding relationship produced

- (i) more multiple homophony when all IMH were considered (i.e. IMH of 2:1 included)
- (ii) more multiple homophony when only the multiple homophony produced was considered (i.e. IMH of 2:1 excluded)

than the processes entering a Complete Feeding or a Conspiring relationship. Thus these results appear to lend support to the theoretical hypotheses. The question is though whether the observed tendency reflects the theoretical motivations which were assumed to give rise to the differential tendency. There is again no way of ascertaining whether it is the presence of both a feeding and a conspiring relationship which gives rise to the higher mean IMH for the processes entering an Incomplete Feeding relationship as compared to the other two relationships.

However, as with the FLOSS-values, it is possible to speculate on the potential effect of an Incomplete Feeding relationship on the IMH by comparing IF/Unaltered PS and Type1IF relationships with the corresponding counter feeding relationships. A higher mean IMH for the Incomplete Feeding relationships in comparison to the counter feeding relationships would indicate that the feeding interaction does indeed have an effect on multiple homophony and the observed tendency of processes entering an Incomplete Feeding relationship to produce more multiple homophony than the Conspiring processes could be assumed to result from the feeding interaction. Table 5.38 (overleaf) indicates that the presence of Incomplete Feeding did indeed have an effect on multiple homophony. Table 5.38 also lends support to the hypothesis that counter feeding relationships have less potential for multiple homophony than their corresponding feeding relationships even though both relationships are potentially compatible with new homophony.

In addition to the four hypotheses listed above we can test some other hypotheses put forward in Chapter 4. Specifically, we can examine the results for any differences between process relationships with unaltered or altered process specifications. The hypothesis postulates that the alteration of process specification

Table 5.38: Mean IMH for IF/Unaltered PS, counter feeding to IF/Unaltered PS, Type1IF and counter feeding to Type1IF: SIWI place

Process Relationship	N	$\sum x$	$\bar{x}$	SD
IF/Unaltered PS	22.11	10	2.21	0.10
co-feed to IF/ Unaltered PS	21.24	10	2.12	0.10
Type1IF	4.34	2	2.17	0.04
co-feed Type1IF	4.13	2	2.07	0.09

entails the potential for less homophony and consequently for lower FLOSS in comparison to process relationships with unaltered process specifications. There is however a problem in the present study in showing whether any observed difference is indeed due to the alteration of process specifications. For instance, in the SIWI position, the processes entering Incomplete Feeding and Conspiring relationships produced a higher mean FLOSS-value for processes with unaltered process specifications than altered process specifications while the opposite result was produced by the processes entering a Complete Feeding relationship. This is shown in Table 5.39 (overleaf). The point is that while in either case it is not possible to show whether the potential alteration of process specification had any effect, the fact that processes with altered process specifications produced higher mean FLOSS-values than those with unaltered process specifications in one instance indicates that the alteration of process specification is not a particularly important factor. This seems also an intuitively reasonable assumption based on the nature of altered process specifications. As was apparent in Chapter 4, the altered process specifications involve segment clusters, which in turn are not likely to be particularly prolific as regards homophony production. Therefore, it seems likely that the observed differences in the FLOSS-values reflect the nature of the processes operating in combinations rather than the alteration of process specifications. These observations are also valid for the corresponding hypotheses concerning multiple homophony put forward in Chapter 4.

As is apparent from Tables 4.3 and 4.4 (Section 4.3.1.2.3), we can make some other comparisons on the basis of the present results. It was for instance hypothesized that Type1IF has potential for higher FLOSS than Type2IF, Type3IF, Type4IF and Type3+4IF in that it consists of both a feeding and a conspiring relationship while the others consist of only either a feeding or a conspiring relationship. For the same reason it was also hypothesized that Type1IF has potential for more multiple homophony than the other four types of Incomplete Feeding with altered process specifications. Again, only the SIWI position can be examined owing to the lack of Incomplete Feeding relationships in the SFWF position. Tables 5.40 and 5.41 (overleaf) summarize the mean

Table 5.39: Mean FLOSS-values for the process relationships operative in the SIWI position as a function of the alteration of process specifications

Process Relationship	U n a l t e r e d P S				A l t e r e d P S			
	N	$\sum x$	$\bar{x}$	SD	N	$\sum x$	$\bar{x}$	SD
Complete Feeding	27	477	17.67	12.18	14	254	18.14	6.82
Incomplete Feeding	12	342	28.50	12.96	37	592	16.00	9.15
Conspiring	56	726	12.96	9.19	10	62	6.20	4.39

Table 5.40: Mean FLOSS-values for Type1IF, Type2IF, Type3IF, Type4IF and Type3+4IF relationships in the SIWI position

Process Relationship	N	$\sum x$	$\bar{x}$	SD
Type1IF	6	70	11.67	8.43
Type2IF	2	65	32.50	12.02
Type3IF	13	142	10.92	6.25
Type4IF	5	79	15.80	4.32
Type3+4IF	9	197	21.89	7.41

Table 5.41: Mean IMH for Type1IF, Type2IF, Type3IF, Type4IF and type3+4IF in the SIWI position

Process Relationship	N	$\sum x$	$\bar{x}$	SD
Type1IF	6	12.34	2.06:1	0.09
Type2IF	2	4.22	2.11:1	0.01
Type3IF	13	26.00	2.00:1	0
Type4IF	5	10.00	2.00:1	0
Type3+4IF	9	18.03	2.00:1	0.01

FLOSS-values and mean IMH for the respective process relationships. As is apparent from these tables there appears to be no support for these hypotheses. It would seem reasonable to assume that the mean FLOSS-values do not necessarily reflect interaction of processes but possibly additive FLOSS-values for the respective processes. While there is no way of determining this in the present study (see below), the absence of multiple homophony for Type3IF, Type4IF and Type3+4IF relationships lends support for this explanation. The presence of multiple homophony would indicate that a feeding interaction had taken place. It must be remembered however, that new homophony may occur without multiple homophony.

It would be interesting and clinically useful to attempt to determine whether the potential compatibility with new homophony is actualized in the present study. Within the present study, this could be examined by comparing the results produced for the combinations of different processes with the respective additive FLOSS-values. There is, however, a problem with those process combinations which have altered process specifications. Because of the potential alteration of process specifications, an additive FLOSS-value does not necessarily reflect the absence of new homophony viz. an altered process specification may 'counter-balance' the presence of new homophony which is then reflected in a FLOSS-value which equals an additive FLOSS-value (see above). But if we accept the argument that an alteration of process specifications is unlikely to have any considerable effect on FLOSS, we can obtain an indication of the new homophony resulting from processes entering into process relationships by comparing the FLOSS-values produced for these combinations with the corresponding additive FLOSS-values. This comparison does not involve processes entering a Complete Feeding relationship or those process combinations consisting of Glottal Replacements since no additive FLOSS-values can be obtained for such combinations (see Chapter 4; Section 4.2.1.2). Table 5.42 (overleaf) summarizes the proportions of non-additive and additive FLOSS-values produced for the different process combinations in the SIWI and the SFWF positions. As Table 5.42 shows a higher proportion of non-additive FLOSS-values were produced for both process combinations in both places in syllable structure except for processes entering an Incomplete Feeding

Table 5.42: The proportion of non-additive and additive FLOSS-values for process relationships: SIWI and SFWF positions

Process	S I W I		S F W F	
Relationship	NA%	A%	NA%	A%
Incomplete Feeding	41	59	57	43
Conspiring	61	39	65	35

Key:

NA = non-additive FLOSS-value

A = additive FLOSS-value

relationship in the SIWI position for which a higher proportion of additive FLOSS-values was evident. It was hypothesized in Section 4.3.1.2.2 that an Incomplete Feeding relationship might not be of crucial importance in the production of homophony in that it is dependent on the operation of processes in clusters. This appears to be borne out by the results in the SIWI position. In the SFWF position, however, for the process combinations concerned, Incomplete Feeding is quite prolific as regards homophony production. For instance, for the process combination k - t and s - 0, the Incomplete Feeding relationship produced a number of instances of new homophony. The subtraction of the corresponding additive FLOSS-value (=46) from the FLOSS-value produced for the combination (=62) indicates the presence of 16 new homophonous pairs. It must be noted however, that new homophony could have been produced not only via Incomplete Feeding but also via 'interaction' of Incomplete Feeding and the operation of the respective individual processes on consonant clusters. This can be illustrated by the following two examples:

e.g. Process 1: k - t

e.g. Process 1: k - t

On the basis of Table 5.42 it can be concluded that the processes studied in the present analysis tended to be compatible with new homophony. This is further supported by the observation that a far greater proportion of the non-additive FLOSS-values were higher than

the additive FLOSS-values rather than lower than such values. This is apparent from Table 5.43 (overleaf). The non-additive FLOSS-values which were lower than the additive FLOSS-values reflect the alteration of process specifications (see Section 4.3.1).

It is now apparent that combinations of two processes which operate in the same or a different place in a word tended to be actually compatible with new homophony in relation to the present data sample. In other words, new instances of homophony were produced as a function of two processes operating in a combination. This does not however necessarily indicate that enough new homophony was produced to enable one to predict potential functional consequences of combinations of two processes on the basis of FLOSS-values of the respective single processes (i.e. Study 1). The question is whether enough new homophony was produced by the process combinations to obscure the effect of the single processes on FLOSS. This can be investigated by determining whether the rank ordering of the FLOSS-values obtained for the combinations of processes is appreciably different from the rank ordering that can be obtained for the corresponding additive FLOSS-values. This can be illustrated as follows. The FLOSS-values obtained for ten process combinations in Study 2 and their additive FLOSS-values calculated on the basis of Study 1 are summarized below for the SIWI position:

Process Combinations	FLOSS-value Study 2	Rank Study 2	Rank Additive	Additive FLOSS-value
k - t;st - t	57	1	1	31
t - d;dr - d	37	2	6	15
l - w;r - w	35	3	3	23
st-t; tr- t	28	4	3	23
l - j;k - t	25	5	2	25
v - b;p - b	22	6	5	21
l - j;r - j	19	7	10	5
g - d;gr - d	16	8	7	14
gr - g;k - g	12	9	8	13
sp - p;l - j	9	10	9	9

Table 5.43: The proportion of non-additive FLOSS-values which are higher or lower than the additive FLOSS-value: SIWI and SFWF positions

Process Relationship	%		%	
	S higher	I lower	S higher	F lower
Complete Feeding	97	3	100	0
Incomplete Feeding	95	5	100	0
Conspiring	95	5	100	0

This example shows that for these ten processes the rank ordering of process combinations is somewhat different. It would not be possible to prioritize adequately the process combinations for treatment on the basis of the additive FLOSS-values only so that the functional consequences of the restricted phonological system would be reflected. While this appears to be the case for the ten processes in this example, we should examine whether this would be the tendency for all the process combinations studied. Spearman's rank order correlations were carried out for

- (1) the process combinations operative in a different place in structure which consisted of HIGH/HIGH independent FLOSS-values
- (2) the process combinations operative in the same place in structure.

It was decided to consider only those process combinations with the HIGH/HIGH independent FLOSS-values operating in a different place in syllable structure since the other process combinations studied at different places in structure produced FLOSS-values which were mainly additive (see Table 5.30 above). Thus, the functional consequences of the operation of such processes are inferable from the FLOSS-values of the respective single processes.

As regards the process combinations operating in the same place in structure the rank order correlations were carried out only for the processes entering an Incomplete Feeding and Conspiring relationships. As was pointed out in Chapter 4, Section 4.3.1.2.1, processes entering a Complete Feeding relationship do not have an additive FLOSS-value in that the first process does not in fact have any opportunity to produce any of the homophony that it would produce if it operated on its own. Furthermore, it was decided to consider Incomplete Feeding and Conspiring relationships together owing to the very similar proportions of non-additive FLOSS-values which were evident for the two process relationships (see Table 5.42 above). Furthermore, the rank order correlations were carried out separately for the SIWI and the SFWF places in structure.

Table 5.44 (overleaf) summarizes the correlation coefficients obtained for the various process combinations. As is apparent from this table all the correlation co-efficients were above 0.9, which indicates a high correlation between the additive FLOSS-values

Table 5.44: Correlation Coefficients

Process Combinations	r	no. of valid cases
D.P.S ; HIGH/HIGH	0.988	54
S.P.S		
SIWI: IF + Con	0.950	139
SFWF: IF + Con	0.991	197

Key:

D.P.S = Different Place in Structure

S P S = Same Place in Structure

IF = Incomplete Feeding

Con = Conspiring

and the FLOSS-values obtained for the combinations of processes. Thus, it can be maintained that the functional consequences of two processes operating in certain combinations can be predicted on the basis of the independent FLOSS-values (i.e. Study 1) for the respective processes.

While it is true that we cannot compare processes entering Complete Feeding relationships to additive FLOSS-values, we can, nevertheless, make some observations about the extent of new homophony produced by such combinations by comparing the FLOSS-values produced to those obtained for the second process in Study 1. All the homophony produced by the second process (i.e. the one that is being fed) is still produced and all the homophony produced other than that indicates the presence of new homophony. Table 5.45 (overleaf) shows that in a great majority of instances more homophony than the amount produced by the second process was indeed produced. We can now ask the question whether enough new homophony was produced to obscure the rank order correlation of the process combinations based on solely on the independent FLOSS-values of the second process. Spearman's rank order correlation was carried out on the basis of the FLOSS-values produced for the process combinations and the independent FLOSS-values of the second process (see Table 5.46, overleaf). As Table 5.46 shows, while the correlation coefficients were lower (in particular in the SIWI position) than the correlations for the Incomplete Feeding and Conspiring relationships, they nevertheless showed a high correlation. This was particularly so in the SFWF position. It can therefore be maintained that the independent FLOSS-values of the second process in a Complete Feeding relationship can give an indication of the potential functional consequences of processes operating in a Complete Feeding relationship. This indication is more likely to reflect actual functional consequences in relation to processes operating in the SFWF position by comparison with the SIWI position.

This section has summarized the FLOSS-values and IMH calculated for the combinations of two processes studied. In addition to rank ordering the values produced, several comparisons between mean FLOSS-values and mean IMH for several groups of processes were carried out. These comparisons were selective, aimed at illuminating

Table 5.45: The proportion of new homophony produced for Complete Feeding relationships: SIWI and SFWF positions

Process Relationship	S I FLOSS > Proc2 %	W I FLOSS = Proc2 %	S F FLOSS > Proc2 %	W F FLOSS = Proc2 %
Complete Feeding	90	10	87	13

Key:
 FLOSS >, = Proc2 = the FLOSS-value obtained for the process combination is bigger or equals the independent FLOSS-value for the second process

Table 5.46: Correlation Coefficients

Process Combinations	r	no. of valid cases
S.P.S		
SIWI: CF	0.686	40
SFWF: CF	0.906	30

Key:
 S P S = Same Place in Structure
 CF = Complete Feeding

the theoretical framework developed for the assessment of the functional adequacy of children's phonological systems. The tendencies observed in this section will be considered further in the next chapter, which discusses the potential role of the theoretical framework in the assessment of children's phonological systems.

CHAPTER 6: DISCUSSION

The discussion of this study falls into two sections which are inter-related. The first section (6.1) will attempt to assess the potential clinical relevance of the theoretical framework developed in Chapters 3 and 4 for the assessment of the functional adequacy of children's phonological systems. The second section (6.2) will then incorporate the results obtained in Study 1 and Study 2 into this evaluation.

6.1: Assessing the Clinical Relevance of the Theoretical Framework

The framework proposed in this study for the assessment of the functional adequacy of children's phonological systems is essentially an applicationally (and, in particular, clinically) oriented one. It was primarily developed with the motivation that it could provide a principled basis for prioritization of treatment goals in the clinical management of phonological disability in children. Furthermore, the central concepts of functional loss and multiple homophony provide a basis for the assessment of the functional adequacy of any restricted phonological system. For instance, in regard to normal phonological development, it would be possible to examine whether phonological contrasts emerge in a fashion which minimizes FLOSS in the phonological system, (see Chapter 7).

The clinical orientation of the framework is further evident in the incorporation of the phonological process analysis framework into the assessment of functional adequacy. It was anticipated that the incorporation of this framework would provide some new insights into phonological process analysis as a means of describing child speech patterns. It would also promote a wider applicability of the present study to the clinical context where process analysis is a common means of describing child speech. This does not, however, imply that it is necessary to describe child speech in terms of phonological processes in order to be able to assess functional adequacy. Indeed, a functionally inadequate phonological system essentially reflects contrastive inadequacy. Therefore, any assessment of children's phonological systems which identifies the contrasts missing from the phonological system can provide the basis for the assessment of functional adequacy of phonological systems.

In regard to the clinical relevance of this study, it has been maintained that the main aim of phonological therapy is to improve

the communicative adequacy of a child's phonological system (e.g. Grunwell, 1981; 1985). However, as has been argued in this study (Chapter 3) the actual assessment of the communicative adequacy of phonological systems is a very complex, if not an impossible, task, and therefore, an assessment of the functional adequacy of the system provides a system-based mean of assessing potential communicative consequences of incomplete phonological systems, (cf. Grunwell's notion of communicative adequacy). Those phonological contrasts, or combinations of contrasts, absent from the phonological system, which carry high FLOSS and IMH have more potential for communicative impairment in that they indicate a higher index of potential homophony. It is, of course, another matter to determine to what extent this potential is, in fact, realised.

When employing the phonological process framework for clinical analysis, treatment goals are concerned with the elimination of phonological processes, and thereby, the establishment of new phonological contrasts. Several authorities have attempted to define principles for the selection of the processes to eliminate, and principles for the determination of the order in which to eliminate the selected processes. There is general agreement that those processes that contribute greatly to reduced intelligibility should be eliminated (e.g. Ingram, 1976; Weiner, 1979; Hodson, 1982; Edwards, 1983; Grunwell, 1985.). In more specific terms, there are suggestions for the elimination of processes that are optional (eg. Edwards, 1983), cause variability or overlapping (e.g. Ingram, 1976; Grunwell, 1981), are idiosyncratic or persisting (e.g. Hodson, 1982; Edwards, 1983; Grunwell, 1985) or result in the greatest homophony (e.g. Ingram, 1976; Edwards, 1983; Grunwell, 1985). In reference to homophony, Leonard (1985:11) suggests that "the selection of adult sounds for treatment may be based on the degree to which the sounds used as substitutions by the child have potential for homophony" (underlined by the present writer). Patterns that are most deviant (e.g. Grunwell, 1985) or apply frequently in child speech (e.g. Edwards, 1983; Hodson and Paden, 1983) are also suggested targets for remediation. Edwards (1983) also advises the selection of patterns that interact. More specifically, she recommends that if two or more processes apply in combinations, therapy should start with the process that occurs alone as well as 'intertwined'. In addition to the selection criteria which directly aim at improving

intelligibility, it is commonly maintained that one should work on the processes most characteristic of early speech (e.g. Ingram, 1976; Weiner, 1979; Edwards, 1983; Grunwell, 1985) i.e. follow the pattern of normal phonological development.

The guidelines for the selection of remedial patterns are generally broad and impressionistic. For instance, it is not clear why Edwards proposed the above selection criteria for 'intertwined' processes. A few authorities have gone a step further beyond the above kinds of descriptive criteria, and have provided more detailed specifications of therapy goals. Hodson (1982) classes phonological processes into levels of phonological performance, which reflect different degrees of intelligibility of child speech (see Table 6.1, overleaf). The processes were assigned to the four levels on the basis of their occurrence in the speech of unintelligible children. The levels are then used for target selection. For instance, a Level 1 pattern with the percentage of occurrence score greater than 40% may need to be 'targeted' before a Level 2 pattern which occurs 100% of the time. The final decisions are, however, made with reference to the child's whole phonological system. In a similar fashion, Hodson and Paden (1983) select only those processes for remediation that occur in more than 40% of the possible contexts on Hodson's Assessment of Phonological Processes (1980). The cut-off point of 40% is suggested because empirical results of clinical work using this approach indicate that processes that occur in fewer than 40% of the words tested are spontaneously eliminated without treatment. The most definite 'order of remediation' is proposed by Weiner (1979:38). He recommends the following order for the processes within each process category.

- (i) Syllable Structure Processes: Deletion of Final Consonants > Glottal Replacement > Weak Syllable Deletion > Cluster Reduction
- (ii) Harmony Processes: Prevocalic Voicing > Final Consonant Devoicing > Velar Assimilation > Labial Assimilation > Alveolar Assimilation
- (iii) Feature Contrast Processes: Stopping > Affrication > Gliding of Fricatives > Fronting > Denasalization > Gliding of Liquids > Vocalization

This recommended order of treatment is based "partially on normal development, ease of instruction and overall effect on intelligibility" (Weiner 1979:38). Weiner does not indicate how exactly these criteria were employed to establish this order, but it

Table 6.1: Levels of Phonological Performance
(from Hodson 1982:104)

LEVEL	PHONOLOGICAL PATTERNS	EXAMPLES		
0	No Obstruents	hat	→	/æ/, /wæ/
I	Syllable Reduction	basket	→	/bæ/
	Omission of Postvocalic or	hat	→	/hæ/, /æt/
	Prevocalic Consonants	watch	→	/wæ/, /ɔt/
	Cluster Deletion	spoon-	→	/un/
	Fronting of Velars	gun	→	/dʌn/
	Backing	Santa	→	/hæŋ kə/
	Glottal Replacement	hat	→	/hæʔ/
	Prevocalic Voicing	cow	→	/gau/
	Prevocalic Devoicing	gun	→	/kʌn/
	Reduplication	basket	→	/bæ bæ/
	Vowel Deviations	bed	→	/bæd/
	Idiosyncratic Rules	basket	→	/bæ wə/
II	Cluster Reduction	spoon	→	/pun/
	Stridency Deletion	soap	→	/oup/, /toup/
	Stopping	leaf	→	/dip/
	Liquid Gliding	red	→	/wɛd/
	Liquid Vowelization	chair	→	/tʃɛv/
III	/θð/ → /f, v, s, z/	thumb	→	/fʌm/, /sʌm/
	Frontal Lisp	soap	→	/sɔup/
	Lateral Lisp	soap	→	/sɔup/
	Tongue Protrusion /t, d, n, l/	doll	→	/dɔl/
	Palatalization	soap	→	/ʃɔup/
	Depalatalization	shoe	→	/su/
	Affrication	shoe	→	/tʃu/
	Deaffrication	chew	→	/ʃu/
	Final Consonant Devoicing	page	→	/pɛtʃ/
The following may occur at all Levels except Level 0.				
	Assimilation	spoon	→	/fpun/
	Coalescence	spoon	→	/fun/
	Metathesis	mask	→	/nɪæks/
	Epenthesis	black	→	/bɔlæk/
	Diminutive	fork	→	/fɔɹkɪl/

would appear that the prioritization rests mainly on subjective evaluation. Whereas such an order is better than nothing at all, it is no substitute for an order of remediation based on objective criteria. The importance of treatment planning based on objective linguistic principles has indeed been much emphasized in the literature on clinical linguistics in recent years (e.g. Connolly, 1980; Crystal, 1981; Grunwell, 1985; Ingram, 1986).

While it must be recognised that the specific targets must always be based on the analysis of the phonological capabilities of each individual child, we nevertheless need some information about the 'characteristics' of the patterns identified to be able to select one pattern over another for remediation. More specifically, we need to be able to identify in some principled way which sound contrasts need to be established first in the child's phonological system to promote its functional and communicative adequacy. The fact that most studies which have combined linguistic analysis with therapy have avoided the issue of what to teach first is not surprising. It is indeed doubtful whether the concept of communicative adequacy can ever be 'pinned down' in precise enough terms to allow the investigation of the issue of remedial primacy in any great detail. However, Connolly (1984) provides some guidelines, which should prove useful when determining which characteristics of disorderd speech may give rise to unintelligibility. He proposed that intelligibility may be affected by (i) the obliteration of contrasts (ii) the confinement of the obliteration of contrasts to certain linguistic environments (iii) the functional load of each obliterated contrast (iv) the degree of difference between the target sound and its realisation (v) the frequency of the abnormality in the patient's speech (vi) the degree of consistency in the target- realization relationship. On the basis of the arguments put forward in the present study (see Chapter 3), we can also maintain that FLOSS and IMH measured in terms of homophony resulting from an incomplete phonological system provide objective means of assessing the potential functional and communicative consequences of such phonological systems. In fact, it was argued in Chapter 3, that the functional loss of contrasts is a more direct reflection of not only functional inadequacy, but also communicative inadequacy, of children's phonological systems than the measure of functional load. Furthermore, the introduction of the concept of multiple homophony (ie. IMH) into the assessment of children's phonological systems renders the present assessment more directly

related to communicative adequacy than the concept of functional load. After all, it is the fact that 'obliterated' phonological contrasts in a child's phonological system may result in lexical items being left undifferentiated in the lexical system (ie. presence of homophony), which gives rise to potentially unintelligible speech.

The absence of phonological contrasts in a child's phonological system leads to potential functional inadequacy, and potential communicative inadequacy, of the system by virtue of the system not being able to support the required lexical differentiation in the lexical system. Therefore, if we accept that

"...language intervention can only be pursued
rationally within a theory of language."
(Ingram, 1986:1)

it makes linguistic sense to introduce into the child's phonological system those contrasts, whose absence renders the phonological system more functionally adequate. In other words, those missing contrasts or combinations of contrasts with high FLOSS-values would merit more urgent remedial attention than those with low FLOSS-values. As such, the capacity of the phonological system to signal lexical differences would be maximally improved. Within the framework of phonological process analysis, those phonological processes or combinations of processes with high FLOSS-values would merit more urgent clinical attention than those with low FLOSS-values.

The index of multiple homophony has particular relevance to the prioritization of treatment goals by enabling a more 'communicatively' oriented assessment of functional adequacy. Treatment programmes aiming purely at the improvement of the functional adequacy of children's phonological systems, on the basis of FLOSS, would not directly utilize the IMH. Such an index could, however, provide a principled means for determining the treatment priority for the establishment of those contrasts the absence of which produces equal functional loss in the phonological system (see also Section 6.2 below). In such instances, greater potential for multiple homophony would indicate greater potential for communicative impairment, and therefore treatment prioritization based on indices of multiple homophony would add a 'communicative' dimension to treatment planning based on the assessment of the functional adequacy of the phonological system.

On the other hand, the IMH can also be considered relevant in its own right to treatment planning which specifically aims at the elimination of multiple homophony from a child's lexical system. The motivation for such treatment planning would reflect the potential of

occurrences of multiple homophony for communicative impairment in that several intended meanings would be realized by the same phonemic form. Thus, such treatment planning while still based on system-based linguistic principles, takes a step towards attempting to improve communicative adequacy in a somewhat more direct fashion than the concept of FLOSS. It is yet to be shown, however, in what manner and to what degree, the concepts of FLOSS and multiple homophony are related to communicative adequacy. Furthermore, the concept of FLOSS can be accorded more clinical relevance than the concept of multiple homophony in that FLOSS is the measure of functional adequacy while the IMH is only potentially one of the many factors bearing relevance to the assessment of communicative adequacy. As such, it is maintained that FLOSS provides a more theoretically sound motivation for treatment (see also Section 6.2, below). It remains to be assessed in future studies whether the theoretically strong hypothesis for the relationship between the assessment of functional adequacy of phonological systems and prioritization of treatment goals in phonological therapy holds in the actual clinical management of children with phonological disorders.

The assessment of the functional adequacy of children's phonological systems is only possible after one has determined which phonological contrasts are absent from the phonological system. Thus, this pre-analysis essentially involves the identification of the contrasts missing from a phonological system. While the form of this assessment can take either that of a process analysis or some other kind of assessment (eg. Substitution Analysis - Ingram, 1981; Contrastive Assessment - Grunwell, 1985), it appears that the existing assessment procedures would not be totally adequate to enable the assessment of the functional adequacy of children's phonological systems on the basis of the framework presented in this study. The following criticisms of the existing phonological processes analyses are also applicable to non-process-based contrastive analyses. The procedures for process analysis used in the analysis of child phonologies (namely, Weiner, 1979; Hodson, 1980; Shriberg and Kwiatkowski, 1980; Ingram, 1981; Grunwell, 1985) can be considered inadequate in the following respects:

- (i) They do not consider combinations of processes
e.g. "Often, two or more processes will affect a
substitute at the same time. In those cases
simply enter the substitute separately for each
process..."

(Ingram, 1981:80)

- (2) They do not recognise possible process relationships.
- (3) They do not recognise potential altering of process specifications caused by combinations of processes.

As is apparent from the discussion in Chapter 4, this information is an essential part of the assessment of the functional adequacy of restricted phonological systems. The ability to predict some of the potential functional consequences resulting from the operation of phonological processes (or absence of contrasts) (without recourse to ready calculated FLOSS-values) may prove useful in a clinical setting in that the provision of ready calculated FLOSS-values for the numerous possible combinations of processes (or absent contrasts) is not always practical. Therefore, in order to enable one to make such predictions we may need to know whether processes operate as single processes, or whether they enter into combinations and furthermore, whether the combinations of processes enter into any of the possible relationships discussed in Chapter 4.

Figure 6.1 (overleaf) outlines the manner in which the assessment of the functional adequacy of children's phonological systems can be incorporated into the analysis of child speech leading to suggestions for treatment goals. Figure 6.1 is in the form of a flow-chart. It can be interpreted as follows. If we start with child data and describe it in terms of phonological process analysis, our first task is to determine which, if any, processes operate as single processes and which, if any, processes operate in combinations. The processes which operate as single processes then reveal which contrasts are absent from the phonological system and the functional consequences of the incomplete phonological system is assessed on the basis of ready calculated FLOSS-values and IMH. In regard to the processes operating in combinations it needs to be determined whether the processes operate in the same place in structure in a word and can enter into process relationships or operate in a different place in structure in a word and cannot enter into process relationships (see Chapter 4.) Note also that the same process (=a single process e.g. Fronting k - t) can operate in a different place in syllabic structure simultaneously (see Study 1, Section 5.3) and as such these can also be considered as operating in a different place in structure in the assessment of functional adequacy. According to the theoretical framework, it is not possible to predict potential functional consequences of processes operating in a different place in syllable structure in a word. Therefore, as is shown in Figure 6.1, in such

Figure 6.1: The Assessment of the Functional Adequacy of Children's Phonological Systems

instances functional adequacy can only be assessed in relation to ready calculated FLOSS-values and IMH (but see Section 6.2 below). The establishment of process relationships between two processes operating in the same place in syllable structure will, on the other hand, allow one to make some predictions about potential differential effects of the process relationships on the functional adequacy of a phonological system (see Chapter 4). It is this predictive component of the framework which renders a process analysis somewhat advantageous over analysis of child data which simply concentrate on identifying the contrasts which are present (or absent) in a child's phonological system. The assessment of the functional adequacy of phonological systems described in such fashion requires ready calculated FLOSS-values for all such contrasts. Figure 6.2 (below) exemplifies such a situation.

Figure 6.2: The assessment of the functional adequacy of children's phonological systems described on the basis of a 'contrastive assessment'

It is not easy to conceive how the actual analysis of child data on the basis of Figure 6.1 could be implemented in practice. While it is beyond the scope of the present study to arrive at a practical assessment procedure incorporating the assessment of the functional adequacy of children's phonological systems, it is possible to make some informal, and selective observations on the nature of such a procedure. It would probably not be unduly complicated to establish the operation of single processes: all the processes which do not enter any combinations would be classed as single

processes (i.e. one process operates at a time on a word). This analysis is essentially polysystemic. As was pointed out above, however, single processes operating in different places in syllabic structure can enter into 'combinations' from the point of view of functional inadequacy (cf. Section 4.3.2): such combinations of two processes are potentially compatible with new homophony. Therefore, an analysis of child speech which is oriented towards the assessment of functional adequacy could consider combinations of single processes operating in different places in syllable structure in addition to single processes 'proper' (see discussion on Figure 6.1 above). A decision would have to be made, however, as to whether the assessment of the functional adequacy would be best considered in polysystemic terms in the clinical context. It may become unduly complicated in this context to consider every possible combination of processes with potentially differing functional consequences.

While the present study considers a maximum of combinations of two processes, functional inadequacy of children's phonological systems is most likely often due to the operation of more than two processes simultaneously (i.e. multiple loss of contrasts in a system). This in turn potentially produces a great number of processes operating in different relationships, in different places in structure as well as individually. From the point of view of the management of children with phonological disorders one would, however, need to decide on the maximum number of combined processes which can be realistically assessed in functional terms. This decision in the clinical context would most likely depend on the number of processes one wants to work on at any particular time. For instance, a data sample may exhibit the following Conspiring processes in a word initial position:

e.g. Fronting k - t

Stopping tʃ - t

WI Cluster Reduction st - t

WI Cluster Reduction tr - t

The question is then whether one would attempt to assess the functional consequences of all the four processes operating simultaneously or perhaps consider only combinations of two processes at a time. From a purely practical point of view it would not be feasible to have ready calculated FLOSS-values or IMH for all conceivable combinations of Conspiring processes. It would, of course, be possible to calculate FLOSS-values and IMH for a great

number of process combinations on the basis of demand in the clinical setting if there was a purpose-built computer program for such calculations. In the absence of such a program, however, it will have to suffice to consider only two Conspiring processes at a time. The elimination of processes could then be based on two processes at a time.

Another potential obstacle in the assessment of functional adequacy of children's phonological systems described in terms of phonological processes concerns the difficulty in the identification of Incomplete Feeding relationships and the differentiation between process relationships with unaltered and altered process specifications. One needs to be aware of when the operation of context-independent processes in clusters and the operation of two-term cluster reduction patterns can take place. Clinical assessment procedures can, of course, resort to already established relationships such as those in the present study (see Chapter 5) to aid such identifications.

The assessment of the functional adequacy of children's phonological systems essentially involves the identification of those process relationships which are potentially compatible with new homophony. Furthermore, the identification of potential (or actual) alterations of process specifications provides further impetus for differentiating within the relationship categories (eg. Complete Feeding: unaltered or altered process specification). The identification of relationships in child data which are incompatible with new homophony also provides some differential guidelines (namely, Segmental Bleeding, counter feeding and some types of Incomplete Feeding). In the present study Segmental Bleeding will not be considered further. However, as is apparent from Chapter 4, a differential potential for the production of new homophony can be carried by counter feeding to Complete Feeding relationships due to potential alteration of process specifications.

The assessment of functional adequacy in terms of processes and process relationships in the clinical context is carried out on the basis of a child data sample. In other words, the particular child realizations that are analysed must exhibit the existence of the particular processes and process relationships. However, such a strictly data-based analysis could easily leave process relationships unnoticed solely because of a restricted data sample. (Note: The

size of a sample recommended by phonological assessment procedures varies from 100 - 250 different words.) In an alternative analysis, all the potential relationships processes could enter into in a child's speech sample would be identified. In other words, the pre-analysis would simply involve the identification of the presence of processes, (i.e. what the existing process analyses already enable one to do). On the basis of these processes one would then work out all the potential relationships the processes could enter into and one would also work out all the processes which could not enter into any relationships. This would then enable one to assess potential functional consequences of particular phonological systems. While this method dispenses with the problem imposed by a particular lexical sample, it introduces a further problem: process relationships which are not operative for a particular child might be considered in the assessment. A decision would have to be made as regards the kind of process analysis which would be appropriate for the assessment of the functional adequacy of children's phonological systems. It could be a compromise between the two methods described here.

It was anticipated in Chapter 4 that some components of the theoretical framework may not be of appreciable relevance for the actual assessment of functional adequacy. In regard to the concept and measure of FLOSS, its relationship to communicative adequacy may not be a particularly close one. It has been argued that FLOSS is a system-based concept, which gives some indication about the communicative adequacy of the phonological system by assessing the number of lexical items in a lexical system that are left undifferentiated. While this is an appropriate means of assessing the functional adequacy of a phonological system, it has been argued that it does not necessarily reflect the communicative adequacy of the system, which is dependent on a multitude of other linguistic and non-linguistic factors. The concept of multiple homophony has been introduced as a step toward a more 'communicatively' oriented analysis. The actual role of multiple homophony in communication remains to be assessed in relation to listener reactions to homophony. A further step toward an assessment of communicative adequacy of restricted phonological systems would involve the consideration of the following factors:

- (i) It may be necessary to consider whether the homophonous forms produced in a lexical system correspond to the phonemic form used to represent the target concept in the ambient language.

e.g. /tɹɪp/ → /dɪp/ vs /traɪ/ → /daɪ/
 /tɪp/ → /dɪp/ /daɪ/ /daɪ/

It can be argued that the possibility of the listener recovering the intended meaning of a pair of words may be higher if the homophonous form is represented by the appropriate phonemic form for one of the words. For instance, if a child said [daɪ] there is more chance for the correct meaning to be recovered than if a child said [dɪp] for /tɹɪp/ and /tɪp/. In the latter case, the realization [dɪp] adds an extra variable for potential confusability. This would also enable one to assess the differential potential for communicative impairment of actually non-homophonous lexical pairs, which are however potentially homophonous with other forms.

e.g. /tɹɪp/ → /dɪp/ } no actual homophony;
 /traɪ/ → /daɪ/ } potentially homophonous

These two realizations reflect functional adequacy in that the existence of a conceptual distinction is signalled by a differing phonemic form. Factors such as that discussed in (i) and also those in (ii) and (iii) (below) would enable one to determine whether this functional distinction is communicatively valid.

- (ii) it may be necessary to differentiate between homophonous forms produced in a lexical system which are acceptable words of the language and which are not.

e.g. (A) /ki/ → /ti/ vs /seɪn/ → /teɪn/
 /si/ → /ti/ /keɪn/ → /teɪn/
 (B) /kait/ → /taɪt/
 /saɪt/ → /taɪt/

The realizations of [teɪn] for the two concepts most likely alerts the listener more readily to the realization that the form produced does not correspond to the phonemic form usually used for the intended concept.

- (iii) it may be necessary to consider the auditory distances of the differentiating sounds of the target and the realization. It can be hypothesized that the closer the auditory distance the more chance for confusability, (cf. Line, 1987).

While these informal suggestions attempt to add a communicative dimension to the assessment of the adequacy of phonological systems, these hypothetical criteria are still essentially system-based. In other words, they attempt to provide a communicatively oriented means of assessing the effect of an incomplete phonological system on a lexical system. It is, however, very difficult to envisage an assessment of communicative adequacy of a phonological system which is not based on lexical systems. If one were to be devised it would presumably involve the assessment of the effect of actual homophony on communication, and as such would most likely have to be restricted to very small data samples. This in turn would not make for general

applicability of such results. Therefore, the most applicable solution may be a system-based analysis with a communicative dimension. Whether the above suggestions (i.e. i-iii), together with the concept of multiple homophony, would add such a dimension to the assessment would have to be examined in relation to experimental evidence on listener reactions to homophony. In regard to child phonology in particular such experiments would need to study the ability of adults to recover child homophones and, for the sake of completeness, the ability of children to recover other children's homophones. It would depend on the purpose of the particular studies whether the child homophones would include examples for disordered child speech. After obtaining such experimental evidence, it would be no mean task to incorporate the findings into a workable framework which would enable one to carry out the actual assessments. It is beyond the present study to pursue this issue any further.

The ability to be able to make statements about potential compatibility or incompatibility of process relationships with new homophony enables one to put certain process relationships in an order of priority. If we assume, for instance, that we have identified several Complete Feeding relationships with unaltered and altered process specifications and several Type4IF(ii) relationships in an analysis of child data, the former relationships would merit treatment priority over the latter ones due to their being potentially compatible with new homophony. Further differentiation within the Complete Feeding relationships can be made on the basis of the nature of the process specifications: those relationships with unaltered process specifications would merit more urgent clinical attention as being potentially more detrimental to the functional adequacy of the phonological system than those with altered process specifications. It must be noted, however, that the potential effect of altered process specifications on homophony depends on the assumption that context-independent processes are operative in clusters and in the case of Incomplete Feeding, that 2-term cluster reduction patterns (WI position) are also operative in 3-term clusters. It then follows that in the actual analysis of child data we need some evidence for the reality of those patterns giving rise to the alteration of process specifications. For instance, if the following Complete Feeding relationship was identified:

Process 1: $gr \rightarrow g$

Process 2: $\begin{array}{c} \downarrow \\ g \end{array} \rightarrow d \text{ (ex. } gr - dr)$

the alteration of the process specification of the second process would depend on evidence for the operation of the Fronting process in 'gr'-clusters. Yet, it may be unrealistic to consider only those patterns apparent in the actual data sample in the assessment of the functional adequacy of children's phonological systems because of the usually rather restricted data samples upon which clinical assessments are based (see above). Therefore, a decision would need to be made about the way in which the potential alteration of process specifications could be incorporated into the actual assessment of functional adequacy or, indeed, whether potential alteration of process specifications is of any importance in the actual assessment of functional adequacy.

The role of all the Incomplete Feeding relationships introduced in the present study in the actual assessment of the functional adequacy of children's phonological systems appears to be somewhat marginal. While it cannot be disputed from the theoretical point of view, that those Incomplete Feeding relationships which consist of both a feeding and a conspiring relationship have potential for more homophony than those relationships which are only characterized by feeding or conspiring, it is doubtful whether an Incomplete Feeding relationship can in fact have much effect on homophony, (see Section 6.2 below). This is because the input to Incomplete Feeding relationships consists of segment clusters, which in turn have been shown to be less frequent in the spoken language of adults, (e.g. Denes, 1962) and presumably, are also less frequent, in that of children. That is to say that Incomplete Feeding relationships may not have much opportunity to operate. This indeed was an observed tendency in the results in Study 2, (Section 5.4.1). This together with the fact that Incomplete Feeding relationships are not particularly straightforward to identify may render them not worthy of inclusion in an actual assessment of functional adequacy. This is yet another procedural decision which needs to be made in an actual assessment of the functional adequacy of children's phonological systems.

If, nevertheless, we assume that Incomplete Feeding relationships are sufficiently relevant to the assessment of the functional adequacy, we can speculate on the different potential relevance of the different Incomplete Feeding relationships for

actual analysis. While Type2IF relationships are essentially conspiring relationships in that the apparent feeding relationship can have no effect on homophony, they differ from the 'Conspiring' relationships proper in that the process specification of either process can be altered (=ie. Condition A/B) (see Chapter 4). As such it appears relevant to identify Type2IF relationships separately from Conspiring relationships. It is however questionable whether the difference between Type2IF and Conspiring relationships is appreciable enough to take this distinction into account in an actual analysis of functional adequacy. To put this in other words, it is questionable whether actual analysis of child data should attempt to make a distinction between Condition A and B in regard to Incomplete Feeding relationships, (see also Study 2; Section 5.4.1). While there is more justification for making this distinction for some of the Incomplete Feeding relationships (i.e. Type2IF and Type4IF(ii)) there is not much point in doing so for some of the others (i.e. Type1IF, Type3IF, Type4(i)IF and Type3&4IF). Table 6.2 (overleaf) summarizes the reasons for these distinctions. This is yet another procedural decision which would need to be made in an actual analysis.

There are some other points about Incomplete Feeding relationships which are pertinent to the discussion on actual assessment of functional adequacy. The importance of Type3IF relationships for FLOSS and multiple homophony is doubtful. From the theoretical angle, it was maintained that Type3IF has more potential for multiple homophony than the other types of Incomplete Feeding. In actual data analysis this is most likely not so owing to the relative difficulty of establishing these types of relationships amongst phonological processes. Similarly, the establishment of Type 4IF(ii) relationships may not be of great importance in the actual assessment of the functional adequacy in that such relationships are incompatible with new homophony. Even though some of the Type4IF(ii) relationships have potential for producing less homophony than the corresponding additive value for the single processes, it may not make procedural sense to differentiate these relationships from single processes.

This last point is also pertinent to the various counter feeding to Incomplete Feeding relationships. It can be argued that while the counter feeding to the IF/unaltered PS relationships and to Type1IF and Type2IF relationships are

Table 6.2: Incomplete Feeding relationships with altered process specifications and their relationship to Conditions A and B

Type of Relationship	Differences between Conditions A and B
Type1IF	Conditions A and B differ by the nature of the altered PS's; difference totally dependent on a lexical sample
Type2IF	Conditions A and B differ in that for A the altered PS has no potential for homophony while such potential is present for B
Type3IF	Conditions A and B differ by the nature of the altered PS; difference totally dependent on a lexical sample
Type4IF(i)	Conditions A and B differ by the nature of the altered PS; difference totally dependent on a lexical sample
Type4IF(ii)	Conditions A and B differ in that for A the altered PS has no potential for homophony while such potential is present for B
Type3+4IF	Conditions A and B differ so that in B only a Type3IF relationship operates
Type5IF	No difference

essentially conspiring relationships, they can be given priority in treatment over conspiring relationships 'proper' in that they indicate the presence of the potential for an Incomplete Feeding relationship.

The discussion in this section on the clinical relevance of the theoretical framework for the assessment of the functional adequacy of children's phonological systems has been essentially selective and informal. It is self-evidently difficult to assess applicational relevance of a framework without actually attempting to apply it. It therefore remains to be shown whether the theoretical relationship between the concepts of FLOSS and multiple homophony and treatment planning hold in actuality. In this section, some issues which appear pertinent to this evaluation have been considered. The evaluation can be considered further in light of the results obtained in Chapter 5. This is the focus of the next section.

6.2 Evaluation of Study 1 and Study 2 in relation to the theoretical framework.

The results produced in Studies 1 and 2 provide further clarification of some of the issues discussed in the evaluation of the theoretical framework in Section 6.1. They will also provide some new insights on assessment of functional adequacy. We shall first consider the contributions of Study 1 and Study 2 separately and then draw some general conclusions. In the discussion frequent reference will be made to Figure 6.1 in Section 6.1.

Study 1 provided ready calculated FLOSS-values for a selection of single processes (viz. when one process operates in one place in structure in a word at a time). It also provided ready calculated FLOSS-values and IMH for context-independent processes which operate in all possible places in syllable structure simultaneously. In addition, several tendencies were observed in Study 1 which enable one to assess functional consequences of restricted phonological systems without the necessity of referring to ready calculated FLOSS-values. Firstly, it was observed that the operation of single context-independent processes in the within-word positions did not have any appreciable effect on the functional adequacy as measured in terms of FLOSS. Therefore, it is suggested that single processes operating in the SIWI and SFWF positions should take precedence over single processes operating in the within-word positions in a

remedial programme which aims at improving the functional adequacy of an incomplete phonological system. Furthermore, the processes operating in the SFWF position evidenced a tendency for higher FLOSS as compared to the processes operating in the SIWI position. As such, treatment priority could be given to single processes operating in the SFWF position over those operating in the SIWI position. These findings provide a means of assessing functional adequacy without referring to ready calculated FLOSS-values.

It is frequently emphasized in the literature (eg. Weiner, 1979; Ingram, 1976; Stoel-Gammon and Dunn, 1985) that whole 'sound classes' should be the targets of remediation. While it has been argued in Chapter 4 (Section 4.2), that it is not always appropriate to assess the functional adequacy of restricted phonological systems on the basis of whole 'sound classes' (=process categories), Study 1 provided mean FLOSS-values for each of the process categories consisting of the respective single processes. On the basis of this, we can arrive at the following 'orders of remediation' for the SIWI and SFWF positions.

SIWI: Fronting > Gliding > Prevocalic Voicing > Stopping >
Cluster Reduction

SFWF: FCD > Fronting > WF Devoicing > Stopping > Gliding

Taking into account the tendency for higher FLOSS by single processes operating in the SFWF positions as compared to the SIWI positions, it would appear advisable to work on the process categories operating in the SFWF position prior to those operating in the SIWI position (but see context-independent processes, below). Furthermore, once a process category has been selected for treatment, ready calculated FLOSS-values can be utilized when determining the order of priority for treatment amongst the single processes within the process category (i.e. by reference to the rank order tables in Study 1). It should be noted, however, that the procedural emphasis on process categories ignores the potential of processes within a process category to enter into relationships and as such an approach to the assessment of functional adequacy which is based on 'sound classes' (=process categories) fails to appreciate the full functional consequences of a restricted phonological system. For instance, the mean FLOSS-value for the process category of Stopping does not reflect the fact that several processes within this category conspire to the same segment (e.g. s - t ; ʃ - t ; tʃ - t).

A further problem with the utilization of process categories in the assessment of functional adequacy, and subsequent treatment planning, hinges upon the fact that the separate processes within a process-category may not always be evidenced in a child data sample. Thus, it would be unreasonable to prioritize 'gliding' before 'stopping' in the SIWI position if the process l-w was the only process operative in the process category 'gliding', while 'stopping' was evidenced by several different processes. It thus seems appropriate to suggest that the assessment of the functional adequacy of children's phonological systems is to be based on an analysis of processes rather than process categories (see also Chapter 4, Section 4.2). Nevertheless, the results produced for the process categories provide a crude indicator of potential functional consequences of such categories for clinicians who wish to operate on such basis. It needs to be noted, however, that the appropriateness of processes rather than process categories in the assessment of the functional adequacy does not entail going back to the one sound at the time approach to treatment. The focus is still on phonological contrasts in a treatment programme based on FLOSS but the point about abandoning process categories (or sound classes) as the focus of attention hinges upon the fact that compounded loss of contrasts (resulting in extensive homophony) may result from processes from different process categories operating in combinations (eg. Fronting k - t and Stopping s - t; A Conspiring relationship).

Another comparison which was carried out in Study 1 examined the operation of the three process-categories consisting of context-independent processes in the SIWI and the SFWF positions. A tendency for higher mean FLOSS in the SIWI by comparison with the SFWF position for these process categories was observed. The application of this information in the clinical setting again presupposes that one works on whole process categories. It also introduces an apparent contradiction: it was suggested above that one should work on the process categories operative in the SFWF position first in view of the tendency for higher FLOSS for single processes operative in this position in comparison with the SIWI position. It is now clear that this tendency was probably produced by the process categories consisting of context-dependent processes. Therefore, the determination of which process categories to work on first depends on

- (i) whether the treatment programme concentrates on a particular place in syllable structure, or
- (ii) the specific process categories.

In other words, if one wants to work on process categories in the SIWI or the SFWF places irrespective of the processes and process categories, then one can utilize the 'orders of remediation' given above. If, on the other hand, one wants to work on particular processes irrespective of the place in syllable structure then the prioritization depends on the nature of the processes (ie. context-independent or context-dependent). However, a problem of prioritization in relation to context-dependent processes may arise if there are two process categories as candidates for remediation and the process categories consist of processes which operate in different places in syllable structure (eg. Prevocalic Voicing (SIWI) vs. F.C.D.). According to the results in Study 1, in such instances precedence can be given to those process-categories operating in the SFWF position over those operating in the SIWI position. In addition, a problem of prioritization may arise if one wanted to work on a process category consisting of context-independent processes and one wanted to work on this category in either the SIWI or the SFWF position first (eg. Stopping). Without referring to ready calculated FLOSS-values (but following the tendencies observed in Study 1) precedence should be given to the SIWI position over the SFWF position in such instances. It must be noted that the motivation for a certain type of remedial approach (viz. emphasis on processes/process categories vs. emphasis on place in syllable structure) ultimately depends on the pronunciation patterns of each individual child and these suggestions are at the present only theoretical possibilities justified on the basis of the findings of this study.

It was also found in Study 1 that only a very negligible amount (1 instance) of new homophony was produced when the context-independent processes operated in all places in syllable structure simultaneously. Therefore, it was maintained that the FLOSS-values for such operation of processes are simply additive from the values for the operation of the process in the different places separately. This observation provides an additional means of assessing functional adequacy in the absence of ready calculated FLOSS-values: the functional consequences can be assessed in relation to the corresponding FLOSS-values for single processes (see different-place-in structure below).

Finally, no multiple homophony was produced by either those single processes which had potential for multiple homophony (see Chapter 5, Section 5.3) or by the context-independent processes which operated in all places in syllable structure simultaneously. Therefore, it can be maintained that the IMH is of no importance in the assessment of functional adequacy of restricted phonological systems which can be described in terms of single processes: i.e. when a process operates singly (i.e. not in combination with other processes) in a lexical system (see also below).

The rank ordering tables in Study 2 which summarize all the FLOSS-values and IMH produced can also be used as a means of prioritizing treatment goals for a remediation programme which aims at eliminating homophony from a lexical system, and consequently, from speech. Since Study 2 examines the operation of two processes on the lexical sample at the time, the usefulness of the results depends on

- (i) whether an individual child's data can be described in terms of two processes and process relationships (see Section 6.1 above)
- (ii) whether the remediation programme aims to eliminate processes in combinations of two (see Section 6.1 above).

These kinds of procedural decisions are beyond the scope of the present study. The following discussion is therefore based on the presupposition that analysis of data in terms of single processes (i.e. results discussed above) and combinations of two processes has potential relevance for the analysis of data in a clinical setting (see further below).

From the theoretical point of view, the assessment of the functional consequences of combinations of two processes operating in a different place in syllable structure simultaneously cannot be carried out without referring to ready calculated FLOSS-values and IMH. However, the results in Study 2 provide some means of carrying out such assessment without ready calculated values for such combinations. The results indicated that not enough new homophony was produced by the fact that the two processes operated simultaneously on the lexical sample to diminish the influence of the FLOSS-values obtained for the two processes when they operate as single processes (=independent FLOSS-values). In other words, if two processes with high independent FLOSS-values operated in such a combination their potential for FLOSS would be greater than if two processes with a combination of low and high or low and low independent FLOSS-values operated. Therefore, in the absence of ready

calculated FLOSS-values for such combinations of processes it is possible to predict the potential functional consequences on the basis of the corresponding independent FLOSS-values. The following order of treatment priority for such combinations of processes emerges on the basis of the results.

<u>SIWI</u>	<u>SFWF</u>	
<u>I - FLOSS</u>	<u>I - FLOSS</u>	
HIGH	HIGH	
	before	Key:
LOW	HIGH	I - FLOSS =
	before	independent
HIGH	LOW	FLOSS-value
	before	
LOW	LOW	

In the actual assessment of functional adequacy it may be difficult to determine which independent FLOSS-values should be credited the status of 'high' and 'low'. The manner in which the processes were assigned into the categories of 'high' and 'low' in the present study provides some guidelines as to how this can be done. It must be noted, however, that the difference between high and low independent FLOSS-values in Study 2 were extreme in that the very highest and lowest values were selected for analysis. Many of the low independent FLOSS-values were in fact zero.

It was also maintained in Study 2 that the tendency for higher FLOSS for those processes with LOW/HIGH rather than HIGH/LOW independent FLOSS-values is a reflection of the effect of deletion processes operating in the SFWF position. However, this does not imply that if deletion processes were absent in the SFWF position in a particular child's data we could not employ the above order of prioritization. The results in Study 2 indicated that if the processes operating in the SFWF position were substitution processes with high independent FLOSS-values, the potential functional consequences of such LOW/HIGH combinations would still be potentially more detrimental than the combinations of processes with HIGH/LOW independent FLOSS-values. These observations are in accordance with the tendency for higher FLOSS for single phonological processes operating in the SFWF by comparison with the SIWI position (i.e. Study 1). This in turn lends further support to the finding that the functional consequences of two processes operating in different places in syllable structure are predictable from their independent FLOSS-values.

The above order of priority for treatment is useful only if the process combinations to be compared consist of the different combinations of 'high' and 'low' independent FLOSS-values (ie. not 'high and high' or 'low and low'). The question is whether any predictions about potential functional consequences can be made when the process combinations to be compared consist of the same combinations of 'high' and 'low' independent FLOSS-values (ie. 'high and high' or 'low and low'). The fact that more FLOSS-values which were 'non-additive' rather than 'additive' were produced when process combinations operated in different places in structure indicates that new homophony was produced by these combinations. This observation would then indicate that the potential for FLOSS of such process combinations is not predictable from the corresponding independent FLOSS-values, in particular in relation to combinations of 'high' and 'low' independent FLOSS-values. It was however also maintained that even though new homophony was produced it was not enough to obscure the effect of the independent values. Therefore, it can be maintained that the functional consequences of restricted phonological systems described in terms of the operation of two phonological processes in different places in structure can be predicted from the corresponding independent FLOSS-values (ie. sum of the independent FLOSS-values = additive). This can be illustrated as follows:

(1)	SIWI:	l - w	(high independent FLOSS-value)
	SFWF:	t - ø	(" " ")
(2)	SIWI:	θr - θ	(low " ")
	SFWF:	k - t	(high " ")
(3)	SIWI:	k - t	(high " ")
	SFWF:	ʃ - ø	(low " ")
(4)	SIWI:	pr - p	(low " ")
	SFWF:	ŋ - n	(low " ")

The 'order' of remediation established above would put these into the order 1 > 2 > 3 > 4. The actual FLOSS-values obtained for these combinations in Study 2 would also put these in the same order, i.e. 1(FLOSS=54) > 2(FLOSS=23) > 3(FLOSS=21) > 4(FLOSS=4). This order is also obtained if we simply consider the sum of the independent FLOSS-values (= additive FLOSS), i.e. 1(FLOSS=48) > 2(FLOSS=23) > 3(FLOSS=21) > 4(FLOSS=4). It may not always be the case that the

various orders established on these bases match perfectly. But the point is that in general the functional consequences of two processes operating in different places in syllable structure can be predicted on the basis of the respective additive FLOSS-values (=single processes).

It was also shown in Study 2 that multiple homophony was only produced by combinations of those processes operative in different places in structure which consisted of two high independent FLOSS-values. Furthermore a high proportion of such combinations produced multiple homophony. It can be therefore maintained that FLOSS-values for such combinations of processes are indicative of the presence of multiple homophony. This provides a means of assessing functional adequacy without referring to ready calculated IMH.

Several observations about the assessment of the functional consequences of combinations of two processes operating in the same place in syllable structure can also be made on the basis of the results obtained in Study 2. It was maintained in the theoretical discussion in Chapter 4 (Section 4.3.1.2) that high FLOSS-values do not necessarily reflect high IMH when two processes operate in a combination in the same place in structure, since the presence of new homophony can be the result of two identical homophonous forms (cf. multiple homophony reflects more than two identical forms). While the results for Study 2 indicated that indeed new homophony was produced without the presence of multiple homophony (ie. FLOSS-values for a combination of two processes were 'non-additive' with an IMH of 2:1), a high correlation between high FLOSS and high IMH was observed (see also different place in structure, below). This provides another means of assessing functional adequacy without the need to refer to ready calculated IMH: the potential for multiple homophony produced by combinations of two processes operating in the same place in structure can be predicted on the basis of FLOSS-values. The results in Study 2 also give an indication of what can be considered as high FLOSS-values in the assessment of the functional adequacy of children's phonological systems. For instance, it can be predicted that a combination of two processes with a FLOSS-value of 25 reflects a greater potential for multiple homophony than a process combination with a FLOSS-value of 10. In practical terms, it

is obviously difficult to determine how large a difference between two FLOSS-values needs to be to enable one to make these predictions with any confidence (eg. $FLOSS_1 = 25$; $FLOSS_2 = 23 \Rightarrow FLOSS_1$ potential for higher IMH than $FLOSS_2$?).

It was observed in Study 2 that mean FLOSS-value for the processes operating in the SFWF position was higher than the mean FLOSS-value for the processes operating in the SIWI position. This trend was also observed with the operation of single processes in Study 1. This leads one to suggest that the observed tendency in Study 2 may be simply a reflection of the effect of the respective single processes which enter a combination. In other words, the operation of the two processes in a combination does not produce enough new homophony to obscure the effect of the single processes. The predominance of non-additive FLOSS-values for the different process relationships indicates that new homophony was produced. The rank order correlation coefficient measuring the extent of correlation between the FLOSS-values obtained for process combinations and the corresponding additive FLOSS-values indicated, however, that not enough new homophony was produced to obscure appreciably the effect of single processes. Therefore, prioritization of treatment goals can be based solely on the FLOSS-values for single processes. Notwithstanding, as was shown in Chapter 5 (Section 5.4), the actual rank orderings of process combinations on the basis of the computed FLOSS-values or the additive FLOSS-values are not always identical: the correlations only reflect overall patterns. Therefore, at the clinical level a decision would have to be made whether the overall tendencies reflected by additive FLOSS-values suffice in the assessment of functional adequacy or whether one requires more detailed values for such assessment.

The results in Study 2 also indicated several other tendencies as regards FLOSS and multiple homophony. These tendencies are summarized in Tables 6.3, 6.4 and 6.5 (overleaf). The tables can be used in prioritizing treatment goals when ready calculated FLOSS-values for single and/or combinations of processes are not available.

Table 6.3: Tendencies in mean FLOSS-values observed in Study 2

- (1) SIWI < SFWF
- (2) IF > CF > Con; in SIWI position
- (3) CF > Con > IF; in SFWF position
- (4) CF: SFWF > SIWI
- (5) IF: SIWI > SFWF
- (6) Con: SFWF > SIWI
- (7) IF/Conspire > CF; in SIWI position
- (8) IF/Conspire > Con; in SIWI position
- (9) IF/Conspire > Counter-feed; in SIWI position

Table 6.4: Tendencies in mean IMH observed in Study 2

- (1) SIWI > SFWF; for all process combinations studied
- (2) SIWI > SFWF; for those processes which produced multiple homophony
- (3) IF > CF; in the SIWI and SFWF position
- (4) IF > Con; in the SIWI and SFWF position
- (5) CF > Con; in the SIWI and SFWF position

Table 6.5: Tendencies in the proportions of multiple homophony produced

- (1) CF > Con > IF; for all process combinations studied in the SIWI position
- (2) IF > CF > Con; for all process combinations studied in the SFWF position
- (3) IF > Con > CF; for all those processes which produced multiple homophony in the SIWI position
- (4) IF > CF) for those processes which produced multiple
IF > Con) homophony in the SFWF position

Key:

CF = Complete Feeding
 IF = Incomplete Feeding
 Con = Conspiring
 IF/Conspire = an Incomplete Feeding relationship with a
 Conspiring relationship

On the basis of the results obtained in Studies 1 and 2, we can modify Figure 6.1 (Section 6.1). Figure 6.3 (overleaf) reflects the assessment of functional adequacy incorporating the findings of the two studies. In order not to make this figure unduly complex no detailed findings about the functional consequences of processes are incorporated into the figure (e.g. Study 1: processes operating in the SFWF position had potential for greater FLOSS than processes operating in the SIWI position). The zig-zag lines in Figure 6.3 indicate the new components in comparison to Figure 6.1. More specifically, Figure 6.3 shows that:

- (1) it is not necessary to have access to ready calculated FLOSS-values for single processes but certain predictions can be made on the basis of Study 1, which in turn can lead to direct suggestions for treatment planning.
- (2) Functional consequences of combinations of two processes can be predicted on the basis of additive FLOSS-values (= sum of the FLOSS-values for the single processes).
- (3) IMH can be predicted on the basis of ready calculated FLOSS-values or additive FLOSS-values for combinations of two processes.

As is apparent from (2) - (3) all that is absolutely necessary for the assessment of functional adequacy of phonological systems in which two phonological processes operate in combinations is ready calculated FLOSS-values for single processes. In absence of any ready calculated FLOSS-values for combinations of processes, certain predictions about potential functional consequences can be made on the basis of relationships processes can enter into (see Chapter 4 and Section 5.4). Similarly, without access to FLOSS-values for single processes certain predictions (as has been discussed above) about the effect of the phonological processes on the functional adequacy can be made on the basis of the comparisons carried out in Study 1.

In this discussion implications and applications of the theoretical framework for the assessment of functional adequacy in children's phonological systems and the results obtained in Studies 1 and 2 were considered. Particular emphasis was paid on the applicability of the framework for clinical treatment planning. In the next, and final chapter of this thesis, general conclusions are drawn on the basis of the study. In addition, the potential relevance of the framework for the assessment of functional adequacy for the study of phonological systems of linguistically normal children will be considered.

Figure 6.3: The Assessment of the Functional Adequacy of Children's Phonological Systems Incorporating the Findings of Study 1 and Study 2

Chapter 7: Conclusions

This study developed the idea of assessing the functional adequacy of children's (or any; see below) phonological systems which are restricted in terms of their contrastive potential. The concept and measure of FLOSS was introduced to gauge the number of lexical distinctions left undifferentiated in a lexical system when phonological contrasts are absent from the phonological system. Defined as such, FLOSS is a system-based measure which, however, is assumed to provide some indication on the potential communicative consequences of restricted phonological systems. Homophony evidenced in a lexical system is likely to be reflected to some extent in communicative failures. It has been acknowledged, however, that it remains to be shown to what extent system-based indices reflect communicative impairment. Indeed, the relationship may be a very indirect one (see Chapter 3).

While the ultimate goal of phonological therapy is to improve the communicative adequacy of a person's speech, it is necessary to have some principled means of bringing about such improvement (see Chapter 3; Chapter 6, Section 6.1). It has been maintained that it is not a realistic task (at least at the present) to attempt to assess the 'real' communicative consequences of restricted phonological systems. One step toward such an assessment would however involve the assessment of the adequacy of a phonological system in relation to a lexical system in a manner which incorporates some communicatively relevant dimensions into the assessment (see Chapter 6; Section 6.1). What exactly these communicatively relevant dimensions would be needs to be determined on the basis of experimental work on the effect of homophony on adequate communication (see also below). As a small step toward such a 'communicatively' oriented assessment a measure of multiple homophony (IHM) in a lexical system has been introduced. It has been hypothesized (which hypothesis remains to be tested) that there is more potential for confusability when one homophonous form realizes several lexical targets in comparison with one homophonous form realizing one lexical target.

It has been argued in this study (see Chapters 3 and 6) that the assessment of functional adequacy of phonological systems in

terms of FLOSS and IMH can be useful in the clinical setting by providing a means of determining which missing contrasts in the phonological system are most destructive to the signalling of lexical distinctions. This in turn provides a principled means of prioritizing therapy goals. In light of this observation, FLOSS-values and IMH have been calculated for processes commonly found to operate in the speech of phonologically normal (see below) and disordered children on the basis of a 'representative' sample of children's vocabulary (see Chapter 5). Prioritization of treatment goals on such a basis promotes principled elimination of homophony from lexical systems, the adequacy of which is a probable contributing factor for adequate developmental and communicative functioning. However, all treatment planning is ultimately based on individual cases and the present study provides only general guidelines for such planning (see Chapter 6 and below).

A substantial component in the model developed involved the identification of process relationships (see Chapter 4; Section 4.3). Phonological processes can operate more than one at a time on a word and such processes can enter into process relationships. In order to keep the present study in manageable proportions, only combination of two processes were studied. The recognition of the potential relationships processes can enter into provides a means of predicting the potential functional consequences of the processes which enter such relationships. This, at least in principle, enables the prioritization of treatment goals without the need to resort to ready calculated FLOSS-values or IMH for all combinations of processes. Studies 1 and 2 provide further indications of such predictions. The potential usefulness of the framework developed and of the values obtained for treatment planning remains to be tested in a clinical situation. This would involve the identification of treatment goals on the basis of this study and evaluation of the effect of the selection of such specific treatment goals on any change in a child's phonological system.

It has been pointed out (Chapter 6) that it is not at all clear how the assessment of functional adequacy, in particular with reference to combinations of processes, would be carried out on actual child speech data. Certain basic suggestions have however emerged. It has been shown that a phonological process analysis

framework provides a suitable means of describing data for the assessment of functional adequacy. This approach, it is argued, is a more illuminating way of describing child speech than a procedure which simply identifies the contrasts which are absent/present in a child's phonological system (cf. Figures 6.1 and 6.3 vs. Figure 6.2; Chapter 6). The phonological process analysis framework enables the identification of the potential compounding effects of more than one missing contrast on homophony.

However, existing process analysis frameworks do not identify combinations of processes and, therefore, in order to reveal functional inadequacies resulting from a multiple loss of contrasts, an improved phonological analysis framework needs to be developed. This development would need to be data-based in order to be able to decide which kinds of process combinations and relationships provide an appropriate characterization of children's speech patterns. It has already been established that children's speech patterns can be described in terms of combinations of processes and sometimes the combinations need to be ordered to reflect the particular speech patterns (see Chapter 2, Section 2.2). The exact extent to which process combinations and ordering constraints figure in children's speech remains to be systematically studied. Development of such a framework of process analysis would also shed light on the potential usefulness of the theoretical framework developed in this study.

It has also emerged that the assessment of functional adequacy needs to be based on processes rather than process categories (see Chapter 6; Section 6.1) in order for the assessment adequately reflect the potential compounded effects of missing contrasts on FLOSS and multiple homophony. Processes rather than process categories also enable the description of children's speech in more detailed terms (see Chapter 4; Section 4.2). Thus, the remedial approach implied by the process oriented assessment does not advocate treatment of 'sound classes' (i.e process categories), which basis for treatment has been an 'article of faith' in the phonological literature for some time now, but rather it recommends the treating of combinations of contrasts which may or may not belong to the same process categories and which have a compounding effect on functional inadequacy.

While the emphasis of this study has been on the assessment of

disordered phonological systems of children, it has been mentioned throughout the discussions that the model developed and the values calculated can also be useful in the study of normal phonological development. (The following suggestions are also relevant for a study of disordered phonological development). More specifically, it would be insightful to evaluate on the basis of the values calculated whether

- (i) FLOSS correlates with the order and progress of phonological change in developing phonological systems. Is there evidence for the development of contrasts with high FLOSS before those with low FLOSS?
- (ii) excessive homophony is or is not tolerated in children's productive vocabulary. Is there evidence for homophony avoidance which can be explained in terms of FLOSS?
- (iii) FLOSS and multiple homophony relates to intelligibility of children's speech. Is the presence of homophony in lexical systems relatable to communicative impairment?

Investigation of issues such as those outlined in (i) - (iii) would contribute towards an increased understanding of phonological development and of the factors which may give arise to unintelligible speech (see also Chapter 6; Section 6.1). The examination of (i) would involve the comparison of FLOSS-values with a chronology of phonological development described in terms of phonological processes. A positive correlation of FLOSS and the emergence of contrasts would indeed provide some interesting, and clinically useful, information about the nature of phonological development. The study of (i) would be closely linked with (ii) which would involve a comparison of homophony predicted on the basis of the theoretical model and the calculated FLOSS-values and IMH and actual homophony in a child's speech. As such, the present study can provide a basis for studying homophony avoidance. In regard to investigation (iii), it would need to be tested whether homophony contributes, and what is the extent of this contribution, to unintelligible speech. The study of issues such as (i) - (iii) would in turn provide further impetus for an investigation of the potential usefulness of the present study in the prioritization of treatment goals. If homophony is an important factor in children's

speech and if phonological contrasts normally develop in a fashion which minimizes FLOSS in the phonological system then there is justification for basing treatment goals on the values produced in the present study.

While the present study has concentrated on the assessment of children's phonological systems in functional terms, the concepts and measures developed are applicable to the study of any phonological system which is restricted in terms of its contrastive potential. FLOSS-values and IMH can be calculated on the basis of adult lexical samples reflecting varying states of incomplete phonological systems. Such studies may not only be of interest in the clinical context but also in the context of foreign language learning. Prioritization of 'teaching goals' could indeed be based on FLOSS-values and IMH to promote maximum lexical differentiation in a foreign language. While this is a valid area of application in principle, in practice the teaching of phonology in the foreign language learning context is not common, and thus such values would most likely not be much utilized.

The present study has been somewhat selective in some of the areas it has studied (e.g. only combinations of two processes) and has to a certain extent been restricted by computational considerations (Chapter 5, Section 5.2.2). It has also been necessary to discuss certain issues very briefly (e.g. FLOSS and frequency of occurrence; Chapter 6, Section 6.1) in order to keep the study to reasonable proportions. However, it seems that a reasonably coherent model for the assessment of the functional adequacy of children's phonological systems has been developed and some potentially useful values have been calculated. As with most research, one arrives at the conclusion that more work needs to be carried out in order to be able to assess and realize the full potential of the findings and achievements. Such a conclusion, however frustrating it may seem, is also an encouraging one: research not only advances existing knowledge but also opens up new avenues for future work.

REFERENCES

- Aitchison J. and Chiat S. (1980): Natural Phonology and Recall Mechanisms; Working Papers of the London Psycholinguistics Research Group, 2:17-29
- Anderson J. and Jones C. (1974): Three Thesis Concerning Phonological Representations; Journal of Linguistics 10(1):1-26
- Applegate J.R. (1961): Phonological Rules of a Subdialect of English; Word 17:186-193
- Bailey C-J.N. (1978): Gradience in English Syllabization; Indiana University Linguistics Club
- Beresford R. and Grady P.A.E. (1968): Some Aspects of Assessment; British Journal of Disorders of Communication 1:28-35
- Bernthal J.E. and Weiner F.F. (1976): A Re-examination of Sound Omission - Preliminary Considerations; Journal of Child Communication Disorders 1:132-138
- Branigan G. (1974): Syllable Structure and the Acquisition of Consonants; Mimeo; Boston University
- Burrough G.E.R. (1957): A Study of the Vocabulary of Young Children; Edinburgh; Oliver and Boyd
- Cairns H.S. and Williams S. (1972): An Analysis of the Substitution Errors of a Group of Standard English-speaking Children; Journal of Speech and Hearing Research 15:811-820
- Camarata S. and Gandour J. (1984): On Describing Idiosyncratic Phonologic Systems; Journal of Speech and Hearing Disorders 29:262-266
- Chafe W.L. (1967): The Ordering of Phonological Rules; International Journal of American Linguistics 34:115-136

Chomsky N. and Halle M. (1968): The Sound Pattern of English; New York; Harper and Row

Cole P. (1973): Mutual Bleeding and the Ordering of Phonological Rules; in Kisseberth C.W. (ed.): Studies in Generative Phonology; Jupiter Press; Italy pp. 42-71

Compton A.J. (1970): Generative Studies of Children's Phonological Disorders; Journal of Speech and Hearing Disorders 35:315-339

Compton A.J. (1975): Generative Studies of Children's Phonological Disorders: A Strategy for Therapy; in Singh S. (ed.): Measurement Procedures in Speech, Hearing and Language; Baltimore; University Park Press pp. 55-90

Connolly J.H. (1980): An Explanatory Role for Linguistics in Relation to Speech Therapy; Belfast Working Papers in Language and Linguistics 4:85-98

Connolly J.H. (1984): Speech Intelligibility: A Clinical Linguistic Perspective; Unpublished Paper; Leicester Polytechnic

Connolly J H (1986): Functional Linguistics and the Planning of Remediation; paper presented at a BAAL conference; Leicester Polytechnic

Crocker J.R. (1969): A Phonological Model of Children's Articulation Competence; Journal of Speech and Hearing Disorders 34:203-213

Cruttenden A. (1979): Language in Infancy and Childhood; Manchester University Press

Crystal D. (1972): The Case of Linguistics: a Prognosis; British Journal of Disorders of Communication 7:3-17

Crystal D. (1981): Clinical Linguistics; Vienna; Springer

Crystal D. (1982): Profiling Linguistic Disability; London; Edward Arnold

Derwing B.L. (1977): Is the Child Really a "Little Linguist"?; in MacNamara J. (ed.): Language Learning and Thought; London; Academic Press pp. 79-84

Donegan P.J. and Stampe D. (1979): A Study of Natural Phonology; in Dinnsen D.A. (ed.): Current Approaches to Phonological Theory; Indiana University Press

Drachman G. (1976): Child Language and Language Change: a Conjecture and some Refutations; in Fisiak J. (ed.): Recent Developments in Historical Phonology; Trends in Linguistics, Studies and Monographs 4; The Hague: Mouton

Dunn C. and Davis B.L. (1983): Phonological Process Occurrence in Phonologically Disordered Children; Applied Psycholinguistics 4:187-207

Edwards M.L. (1983): Selection Criteria for Developing Therapy Goals; Journal of Childhood Communication Disorders; 7:36-45

Edwards M.L. and Bernhardt B.H. (1973): Phonological Analysis of the Speech of Four Children with Language Disorders; Unpublished Paper; Stanford University

Edwards M.L. and Shriberg L.D. (1983): Phonology: Applications in Communicative Disorders; San Diego; College-Hill

Fallows D. (1981): Experimental Evidence for English Syllabification and Syllable Structure; Journal of Linguistics 17:309-317

Farwell C. (1972): A Note on the Production of Fricatives in Linguistically Deviant Children; PRCLD 4:63-104

Fee J. and Ingram D. (1981): Reduplication as a Strategy of Phonological Development; Journal of Child Language 9:41-54

Fischer-Jørgensen E. (1975): Trends in Phonological Theory: A Historical Introduction; Copenhagen; Akademisk Forlag

Ferguson C.A. (1978): Learning to Pronounce: The Earliest Stages of Phonological Development in the Child; in Minifie F.D. and Lloyd L. (eds): Communicative and Cognitive Abilities - Early Behavioural Assessment; Baltimore; University Park Press, pp. 237-297

Ferguson C.A. and Farwell C.B. (1975): Words and Sounds in Early Language Acquisition; Language 51:413-439

Fry D. (1977): Homo Loguens; Cambridge University Press

Fry D. (1979): How did we Learn to do it?; in Lee V. (ed.): Language Development; The Open University Press, pp. 17-35

Fudge E.C. (1969): Syllables, Journal of Linguistics 5:253-286

Gimson A.C. (1977): English Pronouncing Dictionary, 14th edition; Dent

Gimson A.C. (1981): An Introduction to the Pronunciation of English; London; Edward Arnold

Goldsmith J. (1976): An Overview of Autosegmental Phonology, MIT

Greenberg J.H. (1959): A Method of Measuring Functional Yield as Applied to Tone in African Languages; Monograph Series on Language and Linguistics 12:7-16

Grunwell P. (1977): The Analysis of Phonological Disability in Children; Phd Thesis; University of Reading

Grunwell P. (1980): Developmental Language Disorders at the Phonological Level; in Jones F.M. (ed.): Language Disability in Children; Lancaster, MTP Press, pp. 129-158

- Grunwell P. (1981): The Nature of Phonological Disability in Children; London; Academic Press
- Grunwell P. (1982): Clinical Phonology; London; Groom Helm
- Grunwell P. (1985): Aspects of Phonological Development in Later Childhood, in Durkin K. (ed.): Language Development During the School Years; London; Groom-Helm
- Grunwell P. (1985): Phonological Assessment of Child Speech (PACS); Windsor; NFER-Nelson
- Haas W. (1968): Functional Phonetics and Speech Therapy; British Journal of Disorders of Communication 3:20-27
- Hoard J.E. (1971): Aspiration, Tenseness and Syllabication in English; Language 47:133-140
- Hockett C.F. (1955): A Manual of Phonology (= Indiana University Publications in Anthropology and Linguistics); International Journal of American Linguistics, 21(4), Part 1
- Hockett C.F. (1966): The Quantification of Functional Load: a Linguistic Problem; Santa Monica; Rand Corp. Memo RM-5168-PR
- Hodson B.W. (1980): The Assessment of Phonological Processes; Danville; Interstate
- Hodson B.W. (1982): Remediation of Speech Patterns Associated with Low Levels of Phonological Performance; in Crary M. (ed.): Phonological Intervention: Concepts and Procedures; San Diego; College Hill, pp. 97-115
- Hodson B.W. and Paden E.P. (1981): Phonological Processes which Characterize Unintelligible and Intelligible Speech in Early Childhood; Journal of Speech and Hearing Disorders 46:369-373
- Hodson B.W. and Paden E.P. (1983): A Phonological Approach to

Remediation: Targeting Intelligible Speech; San Diego; College Hill

Hooper J.B. (1976): An Introduction to Natural Generative Phonology, London; Academic Press

Hyman L.M. (1975): Phonology: Theory and Analysis; USA; Holt, Rinehart and Winston

Ingram D. (1974): Fronting in Child Phonology; Journal of Child Language, 1:233-241

Ingram D. (1975): Surface Contrast in Children's Speech; Journal of Child Language; 2:287-292

Ingram D. (1976): Phonological Disability in Children; London; Edward Arnold

Ingram D. (1981): Procedures for the Phonological Analysis of Children's Language; Baltimore; University Park Press

Inrgam D. (1985): On Children's Homonyms; Journal of Child Language; 12:671-680

Ingram D. (1986): Explanation and Phonological Remediation; Child Language Teaching and Therapy; 2:1-19

Ingram D., Christensen L., Veach, S. and Webster B. (1980): The Acquisition of Word-Initial Fricatives and Affricates in English between 2 and 6 years; in Yeni-Komshian G., Kavanagh J.F. and Ferguson C.A. (eds): Child Phonology, Volume 1: Production; New York, Academic Press

Ingram D. and Terselic B. (1983): Final Ingression; Topics in Language Disorders 3:45-50

Jakobson R. (1968): Child Language Aphasia and Phonological Universals; The Hague; Mouton

- Kail R., Hale C.A., Leonard L.B. and Nippold M.A. (1984): Lexical Storage and Retrieval in Language-Impaired Children; *Applied Psycholinguistics* 5:37-49
- Khan D. (1976): Syllable Based Generalizations in English Phonology; Indiana University Linguistics Club
- Khan L.M.L. (1982): A Review of 16 Major Phonological Processes; *Language, Speech and Hearing Services in Schools*; 13:66-76
- King R.D. (1967a): A Measure for Functional Load; *Studia Linguistica* 21:1-14
- King R.D. (1967b): Functional Load and Sound Change; *Language* 43:831-852
- King R.D. (1976): In Defence of Extrinsic Ordering; in Koutsoudas A. (ed.): *The Application and Ordering of Grammatical Rules*; The Hague Mouton pp. 76-87
- Kiparsky P. (1968): Linguistic Universals and Linguistic Change; in Bach E. and Harms R.T. (eds): *Universals in Linguistic Theory*; London; Holt, Rinehart and Winston pp. 170-202
- Kiparsky P. and Menn L. (1977): On the Acquisition of Phonology; in MacNamara J. (ed.): *Language Learning and Thought*; London; Academic Press, pp. 47-78
- Klein H.B. (1981): Productive Strategies for the Pronunciation of Early Polysyllabic Lexical Items; *Journal of Speech and Hearing Disorders* 24:389-405
- Kučera H. (1974): Review of R.S. Meyerstein, 1970; *Language* 50:169-175
- Koutsoudas A. (1972): The Strict Order Fallacy; *Language* 48:88-96
- Koutsoudas A. (1980): The Question of Rule Ordering: Some Common

Fallacies; Journal of Linguistics 16:19-35

Koutsoudas A., Sanders G. and Noll G. (1974): The Application of Phonological Rules; Language 50:1-28

Lehman T. (1972): Some Arguments Against Ordered Rules; Language 48:541-550

Leicester Polytechnic Computer Centre (1982): User Guide to CANDE; Leicester Polytechnic

Leonard L.B. (1977): Lexical Considerations in Language Intervention; the Mid South Conference on Communicative Disorders; Memphis, March

Leonard L.B. (1978): The Phonology of Devient Child Language; Word 29:139-147

Leonard L.B. (1979): Language Impairment in Children; Merrill-Palmer Quarterly; 25:205-232

Leonard L.B. (1985): Unusual and Subtle Phonological Behaviour in the Speech of Phonologically Disordered Children; Journal of Speech and Hearing Disorders 50:4-13

Leonard L.B. and Fey M.E. (1979): The Early Lexicons of Normal and Language Disordered Children: Developmental and Training Considerations; in Lass N.J. (ed.): Speech and Language: Advances in Basic Rresearch and Practice Vol 2; New York; Academic Press

Leonard L.B., Miller J.A. and Brown H. (1980): Consonant and Syllable Harmony in the Speech of Language Disordered Children; Journal of Speech and Hearing Disorders 45:336-345

Line P. (1987): An Investigation of Auditory Distance; MPhil thesis; Leicester Polytechnic

Locke J.L. (1979): Homonymy and Sound Change in the Child's

Acquisition of Phonology; in Lass N.J. (ed.): Speech and Language; Advances in Basic Research and Practice Vol.2; New York; Academic Press, pp. 257-282

Locke J.L. (1983): Phonological Acquisition and Sound Change; New York; Academic Press

Lorentz J.P. (1974): A Deviant Phonological System of English; Papers and Reports on Child Language Development 8:55-64

Lorentz J.P. (1976): An Analysis of some Deviant Phonological Rules of English; in Morehead D.M. and Morehead A.E. (eds): Normal and Deficient Child Language; Baltimore; University Park Press, pp. 29-59

Macken M.A. and Barton D.A. (1977): A Longitudinal Study of Acquisition of the Voicing Contrast in American-English Word-initial Stops, as Measured by VOT; Papers and Reports on Child Language Development 14:1-47

Martinet A. (1955): Économie des Changements Phonétiques; Berne; Francke

Maxwell E.M. (1979): Competing Analysis of Deviant Phonology; Glossa 13:181-214

McReynolds L.V. and Elbert M. (1981): Criteria for Phonological Process Analysis; Journal of Speech and Hearing Disorders 46:197-204

Meyerstein R.B. (1970): Functional Load; The Hague; Mouton

Morley M., Court D., Miller H. and Garside R. (1955): Delayed Speech and Developmental Aphasia; British Medical Journal 2:463-467

Moskowitz A.I. (1975): The Acquisition of Fricatives: A Study of Phonetics and Phonology; Journal of Phonetics, 3:141-150

Nice M.M. (1925): A Child Who Would Not Talk; Pedagogical Seminary

Nelson K (1973): Structure and Strategy in Learning to Talk; Monographs of the Society for Research in Child Development, Vol 38

Newton B.E. (1971): Ordering Paradoxes in Phonology; Journal of Linguistics 7:31-53

Noske R.G., Schinkel J. and Smith N.S.H. (1982): The Question of Rule Ordering: some Counter-Fallacies; Journal of Linguistics 18:389-408

O'Connor J.D. and Trim J.L.M. (1953): Vowel, Consonant and Syllable - a Phonological Definition; Word 9:103-122

Oller D.K. (1973): Regularities in Abnormal Child Phonology; Journal of Speech and Hearing Disorders 38:36-47

Olmstead D. (1971): Out of the Mouth of Babes; The Hague; Mouton

Panagos J.M. (1974): Persistence of the Open Syllable Reintepreted as a Symptom of Language Disorder; Journal of Speech and Hearing Disorders 39:23-31

Paul R. and Shriberg L. (1982): Associations between phonology and syntax in speech delayed children; Journal of Speech and Hearing Research 25:536-547

Pollock K.E. (1983): Individual Preferences: a Case Study of a Phonologically Delayed Child; Topics in Language Disorders 3:10-23

Poole I (1934): Genetic Development of Articulation of Consonant Sounds in Speech; Elementary English Review; 11:159-161

Prather E.M., Hendrick D.L. and Kern C.A. (1975): Articulation Development in Children aged Two to Four Years; Journal of Speech and Hearing Disorders 40:179-191

- Priestly T.M.S. (1977): One Idiosyncratic Strategy in the Acquisition of Phonology; *Journal of Child Language* 4:45-65
- Priestly T.M.S. (1980): Homonymy in Child Phonology; *Journal of Child Language* 7:413-427
- Pulgram E. (1970): *Syllable, Word, Nexus, Cursus*; The Hague; Mouton
- Renfrew C.E. (1966): Persistence of the Open Syllable in Defective Articulation; *Journal of Speech and Hearing Disorders* 4:370-373
- Ringen C. (1972): On Arguments for Rule Ordering; *Foundations of Language* 8:266-273
- Rischel J. (1961): On Functional Load in Phonemics; *Statistical Methods in Linguistics* 1:13-23
- Rudes B.A. (1977): Another Look at Syllable Structure; Indiana University Linguistics Club
- Salus M.W. and Salus P.H. (1974): Rule-ordering in Child Phonology; *Canadian Journal of Linguistics*; 19:29-39
- Sander E. (1972): When are Speech Sounds Learned?; *Journal of Speech and Hearing Disorders* 37:55-63
- Schwartz R.G., Leonard L.B., Folger M.K. and Wilcox M.J. (1980): Early Phonological Behaviour in Normal Speaking and Language Disordered Children: Evidence for a Synergistic View of Linguistic Disorders; *Journal of Speech and Hearing Disorders* 45:357-377
- Schwartz R.G., Leonard L.B., Wilcox M.J. and Folger M.K. (1980): Again and Again: Reduplication in Child Phonology; *Journal of Child Language* 7:75-87
- Shannon C.E. and Weaver W (1949): *The Mathematical Theory of Communication*; University of Illinois Press

Shriberg L.D. and Kwiatkowski J. (1980): Natural Process Analysis (NPA): A Procedure for Phonological Analysis of Continuous Speech Samples; USA; Wiley

Smith B. (1979): A Phonetic Analysis Consonantal Devoicing in Children's Speech; Journal of Child Language 6:19-28

Smith M. (1926): An Investigation of the Development of the Sentence and the Extent of Vocabulary in Young Children; University of Iowa Studies of Child Welfare, 3

Smith N.V. (1973): The Acquisition of Phonology: A Case Study; Cambridge University Press

Smith N.V. (1978): Lexical Representation and the Acquisition of Phonology; given as a Forum Lecture; Linguistic Institute; Linguistic Institute of America; Published in Muneo

Snyder L.S. (1979): Communicative and Cognitive Abilities and Disabilities in the Sensorimotor Period; Merrill-Palmer Quarterly 24:161-180

Sommerstein A. (1977): Modern Phonology; London; Arnold

Stampe D. (1979): A Dissertation on Natural Phonology; New York; Garland

Stoel-Gammon C. and Dunn C. (1985): Normal and Disordered Phonology in Children; Baltimore; University Park Press

Templin M.C. (1957): Certain Language Skills in Children, their Development and Interrelationships; Institute of Child Welfare; Monograph Series 26; University of Minnesota Press

Trubetzkoy N.S. (1969): Principles of Phonology; University of California Press

Vago R.M. (1977): In Support of Extrinsic Ordering; Journal of

Wang W S-Y (1967): The Measurement of Functional Load; *Phonetica* 16:36-54

Weeks T.E. (1974): The Slow Speech Development of a Bright Child; USA; Lexington

Weiner F.F. (1979): *Phonological Process Analysis*; Baltimore; University Park Press

Weiner F.F. (1981): Systematic Sound Preference as a Characteristic of Phonological Disability; *Journal of Speech and Hearing Disorders* 46:281-286

Weiner F.F. and Wacker R. (1982): The Development of Phonology of Unintelligible Speakers; in Lass N.J. (ed.): *Speech and Language; Advances in Basic research and Practice Vol. 8*; New York; Academic Press

Wellman B.L., Case I.M., Mengert I.G. and Bradbury, D.E. (1931): *Speech Sounds of Young Children*; University of Iowa Studies in Child Welfare 5

Wepman J.M. and Haas W. (1975): *A Spoken Word Count; Children (Ages 5, 6 and 7)*; Chicago; Language Research Associates

Winitz H. (1969): *Articulatory Acquisition and Behaviour*; New York; Appelton Century Crofts

Woods A., Fletcher P. and Hughes A. (1986): *Statistics in Language Studies*; Cambridge University Press

Yavas M. (1986): A Comparison of Intelligibility Ratings and the Nature of Phonological Systems of Language Disordered Children; a paper presented at Leicester Polytechnic

Appendix 1: The Data Sample

a	as	beat
able	ash	beauty
about	ask	beautiful
accident	asleep	beacuse
ache	ass	bed
acorn	at	bedroom
across	aunt	bee
act	auntie	beehive
add	avenue	beer
aerodrome	awake	beetle
aeroplane	away	beetroot
airplane	awful	before
afraid	axe	beg
after	baby	begin
afternoon	back	behind
afterwards	backward	believe
again	backwards	bell
against	bacon	belong
age	bad	below
ago	badge	belt
aim	bag	bench
air	bake	bend
alive	baker	bent
all	balance	beret
	ball	berry
alley		beside
allotment	ballet	bet
alright	balloon	bib
alone	banana	bicycle
along	band	bike
already	bandage	big
also	bandit	bill
altogether	bang	bin
always	bank	bird
ambulance	bar	birthday
an	barber	biscuit
anchor	bare	bit
and	bark	bite
angel	barn	black
angry	barrel	blackberry
animal	barrow	blackbird
ankle	basin	blackboard
another	basket	blame
answer	bat	blancmange
ant	bath	blanket
any	bathe	bleed
anybody	bathroom	blind
anyone	battery	block
anything	battle	blood
anywhere	be	blossom
apparatus	beach	blouse
apple	bead	blow
apron	beak	blue
arch	beaker	bluebell
arm	bean	bluetit
armchair	beanbag	board
army	beanstalk	boat
around	bear	body
arrow	beard	boil
		bomb

bone
bonfire
bonnet
book
bookcase
bookshelf
boot
bore
born
borrow
both
bother
bottle
bottom
bounce
bow
bowl
box
boy
bracelet
braces
brake
branch
bread
break
breakfast
breath
brick
bridesmaid
bridge
bring
brooch
brook
broom
brother
brown
brush
bubble
bucket
buckle
bud
budgerigar
buffer
build
building
bulb
bull
bullock
bulldog
bullet
bumblebee
bump
bun
bunch
bungalow
bunny
burglar
burn
burst
bury

bus
bush
bust
but
butcher
butter
buttercup
butterfly
button
buy
by
cabbage
cafe

cage
cake
calender
calf
call
camel
camp
can
canal
canary
candle
candlestick
cane
cannon
canteen
cap
cape
captain
car
caramel
caravan
card
cardbord
cardigan
care
creful
carpet
carriage
carrot
carry
cart
case
castle
cat
catch
caterpillar
catkin
cattle
cauliflower
cause
cave
ceiling
chain
chair
chalk
chance
change

chapel
chase
check
cheek
cheese
cherry
chest
chestnut
chicken
chick
chickenpox
child
chimney
chin
china
chip
chocolate
choose
chop
chopper
Christmas
chuck
church
cigarette
circle
circus
clap
class
classroom
clay
clean
clear
clever
climb
cloak
cloakroom
clock
close
cloth
clothes
cloud
cloudy
clown
club
coach
coal
coat
cobweb
cock
cockrel
cocoa
coconut
coffee
coin
coke
cold
collar
collect
colour
comb

come
comic
common
concert
concrete
conductor
cook
cooker
cool
cop
copper
copy
cork
corn
corner
cost
costume
cot
cottage
cotton
couch
cough
count
counter
country
course
cousin
cover
cow
cowboy
crab
crack
cracker
cradle
crane
crash
crate
crawl
crayon
cream
creep
cress
cricket
crisp
crocodile
crook
cross
crow
crowd
crown
crumb
cry
cuckoo
cup
cupboard
curds
curl
currant
curtain

cushion
custard
cut
dad
daddy
daft
dagger
daisy
damp
dance
dandelion
danger
dangerous
dare
dark
dart
date
dawn
day
daytime
dead
dear
deck
decorate
deep
deer
den
dentist
desk
diamond
dice
die
difference
different
dig
dinner
dinnertime
dip
dirt
dirty
dish
ditch
dive
do
doctor
dog
doll
domino
donkey
door
dot
double
down
downstairs
drag
dragonfly
drain
draw
drawbridge
drawer

dream
dress
drill
drink
drip
drive
drop
drown
drum
drunk
dry
duck
dump
dusk
dust
dustbin
duster
dwarf
each
eagle
ear
early
earth
easel
Easter
easy
eat
edge
egg
eiderdown
eight
eighteen
eighty
either
elastic
elbow
electric
elephant
eleven
elf
else
empty
end
engine
English
enjoy
enough
enter
envelope
even
evening
ever
every
everybody
everyone
everything
everywhere
except
excuse
exercise

expect
express
eye
eyebrow
face
fact
factory
fag
fair
fairy
fall
family
fan
fancy
far
farm
farmer
fast
fasten
fat
father
favourite
favour
fawn
feather
fed
feed
feel
feeler
fell
felt
fence
festival
fetch
few
fiddle
field
fifteen
fight
figure
fill
fin
find
fine
finger
finish
fir
fire
fireman
fireplace
firework
first
fish
fisherman
fist
fit
five
fix
flag
flake

flame
flannel
flap
flash
flat
float
floor
flour
flower
fluff
fly
fog
fold
follow
food
foot
football
for
force
forest
forget
fork
fort
fortnight
forward
fountain
four
fourteen
fowl
fox
frame
free
Friday
friend
fright
frightened
frill
frock
frog
from
front
frost
frozen
fruit
fry
full
fun
funny
funnel
fur
furniture
gale
gallop
game
gander
gang
garage
garden
garter
gas

gate
gather
gentle
get
ghost
giant
ginger
gipsy
giraffe
girl
give
glad
glass
glove
glue
go
goal
goat
gobble
God
gold
golden
goldfish
golliwog
good
goodbye
goodnight
goose
grammar
gramophone
grandfather
grand-dad
grandmother
grandma
grapes
grass
grate
grave
gravy
graese
great
green
grey
grip
ground
group
grow
grub
grumble
grunt
guard
guess
gum
gun
hair
hairstresser
half
hall
hello
ham

hammer
hand
handbag
handkerchief
handky
handle
handlebar
hang
hanger
happen
happy
hard
hare
hat
have
hay
he
head
head-dress
heap
hear
heart
haeven
heavy
hedge
hedgehog
heel
help
hen
her
here
herself
hide
high
hill
him
himself
hip
his
hit
hive
hold
hole
holiday
holly
home
honey
hood
hook
hoop
hop
hope
horn
horrible
horried
horse
horseshoe
hose
hosepipe
hospital

hot
hotel
hour
house
how
hum
hump
hundred
hungry
hunt
hurry

hurt
hut
hutch
hyacinth
hymn
I
ice
icing
if
ill
in
Indian
ink
inside
instead
interest
into
iron
island
it
itself
ivy
jacket
jam
jar
jelly
jersey
jet
jigsaw
jingle
job
jockey
join
joke
jolly
jug
juice
jump
jumper
jungle
junior
junk
just
kangaroo
keep
kennel
kettle
key
kick

kid
kill
kilt
kind
king
kiss
kitchen
kite
kitten
knave
knee
kneel
knickers
knife
knit
knob
knock
knot
know
lace
lad
ladder
lady
ladybird
lake
lamb
lamp
lamp-post
land
landing
lane
lantern
lap
large
last
late
laugh
lavatory
lawn
lay
lazy
lead
leaf
lean
learn
leather
leave
leg
leggings
lemonade
lend
leopard
lesson
let
letter
lettuce
library
lick
lid
lie

lift
light
like
lilac
lily
line
lion
lip

lipstick
liquorice
list
listen
little
live
liver
load
loaf
lock
log
lollipop
lolly
lonely
long
look
loose
lorry
lose
lot
loud
love
lovely
low
luck
lump
lunch
lupin
ma
machine
mackintosh
magic
maid
main
make
man
mangle
many
map
marble
march
mark
market
marmalade
marry
master
mat
match
material
matter
mattress
mauve

may
me
meal
mean
measels
measure
meat
meccano
medicine
meet
melt
mend
metal
middle
might
mile
milk
milkman
mill
mince
mind
mine
minute
mirror
miss

mix
model
mole
Monday
money
monkey
month
moon
moor
mop
morning
mother
mum
mummy
motor
mountain
mouse
moustache
mouth
move
mow
much
mud
mudguard
muff
muffin
mug
mule
murder
mushroom
music
must
mustard
my

myself
nail
name
nanny
nasty
nature
naughty
navy
near
nearly
neat
neck
necklace
need
needle
nest
net
never
new
news
newspaper
newt
next
nib
nice
nigger
night
nightdress
nightgown
nine
nip
no
nobody
noise
none
nor
nose
not
note
notebook
nothing
notice
now
nowhere
number
nurse
nursery
nut
nylon
oak
o'clock
of
off
office
often
oil
old
on
once
one

onion
only
onto
open
opposite
or
orange
order
ordinary
other
ought
our
out
outside
oven
over
overall
owl
own
pack
packet
pad
paddle
page
pail
pain
paint
pair
palace
pan
pancake
pansy
panto
pantomime
pantry
pants
paper
parcel
pardon
park
parrot
part
party
pass
passage
past
paste
pastry
pat
patch
path
pattern
pavement
paw
pay
pea
pear
peck
pedal
peel

peep
peg
pen
pencil
penguin
penknife
penny
people
pepper
perhaps
pet
petrol
petticoat
photograph
photo
piano
pick
picture
pie
piece
pig
pigeon
pile
pillar
pillow
pin
pinafore
pinny
pinch
pine
pink
pipe
pirate
pistol
pit
pixie
place
plane
plait
plane
plant
plaster
plastic
plasticine
plate
platform
play
playground
playtime
please
plenty
plough
plug
plum
pocket
poem
point
poison
poke
polar

pole
police
policeman
polish
pond
pony
pool
poor
pop
poppy
porridge
post
postbox
postman
postoffice
pot
potato
pound
pour
powder
pram
prayer
present
press
pretend
pretty
prickle
primrose
prince
princess
print
prize
programme
propellor
proper
pudding
puddle
puff
puffer
pull
pullover
pump
punch
puppet
puppy
purple
purse
push
pussy
put
puzzle
pyjamas
quack
quarrel
quarter
queen
queer
question
queue
quick

quiet
quite
rabbit
race
rag
rail
railway
rain
rake
rasberry
rat
rather
ration
rattle
reach
read
ready
real
reckon
record
red
reed
reel
rein
reindeer
remember
rest
rhubarb
rhyme
ribbon
rice
rich
ride
rifle
right
ring
rip
river
road
rob
robin
rock
rocket
rod
roll
roller
rollingpin
roof
rook
room
root
rope
rose
rosy
rough
round
roundabout
row
rub
rubbish

rude
rug
ruler
run
rush
rust
sack
sad
saddle
sail
salt
same
sand
sandal
sandwich
satchel
Saturday
sauce
saucepan
saucer
sausage
save
say
scale
scare
scarf
school
scissors
scooter
Scotland
scout
scrape
scratch
scream
screw
scribble
scrub
sea
seaside
seat
second
secret
see
seed
seek
seem
seesaw
self
sell
send
servant
serve
set
settee
seven
sew
shade
shadow
shake
shall

shape
share
sharp
shave
she
shed
sheep
sheet
shelf
shell
shelter
shepherd
shine
ship
shirt
shock
shoe
shoot
shop
short
shot
should
shoulder
shout
shove
shovel
show
shred
shut
sick
side
sideboard
sight
sign
signal
silk
sill
silly
silver
since
sing
sink
sister
sit
six
size
skate
skin
skip
skirt
skittle
skull
sky
slap
sledge
sleep
sleeve
sleigh
slide
slip

slipper
slow
slug
smack
small
smash
smell
smile
smoke
snail
snake
snatch
snore
snow
so
soap
sock
sofa
soft
soil
soldier
some
somebody
sometime
something
somewhere
sow
song
soon
sorry
sort
sound
soup
spade
space
spark
sparrow
speak
spear
special
speed
spell
spend
spider
spill
spin
splash
spoil
sponge
spoon
sport
spot
spout
spring
spy
square
squash
squeak
squeeze
squirrel

squirt
stable
stack
stage
stair
stalk
stall
stamp
stand
star
stare
start
station
stay
steal
steam
steep
steeple
step
stick
still
sting
stir
stitch
stock
stocking
stomach
stone
stool
stop
store
storm
story
stove
straight
strange
strap
straw
strawberry
stream
street
stride
string
strip
stripe
stroke
stuff
sty
such
suck
sugar
suit
sum
summer
sun
sunny
Sunday
supper
suppose
sure

surely
surprise
swan
sweat
sweep
sweet
swim
swing
switch
sword
table
tablecloth
tadpole
tail
take
tale
talk
tall
tambourine
tank
tap
tar
tart
taste
taxi
tea
teach
teacher
teapot
tear
teatime
teddybear
telephone
television
tell
ten
tender
tennis
tent
terrible
than
thank
that
the
their
them
themselves
then
there
these

they
thick
thimble
thin
thing
think
third
thirsty
thirteen

thirty
this
thorough
those
though
thought
thread
three
throat
through
throw
thumb
thunder
Thursday
tick
ticket
tickle
tidy
tie
tig
tiger
tight
tile
till
timber
time
tin
tiny
tip
tire
tired
to
toad
toast
tobacco
today
toe
toffee
together
toilet
tomato
tommygun
tomorrow
ton
tongue
tonight
too
tooth
toothpaste
top
torch
tortoise
toss
touch
towel
tower
town
toy
trace
track

tractor
traffic
trailer
train
tram
trap
tray
treacle
tread
treasure
tree
triangle
trick
trip
trolley
trouble
trouser
trowel
truck
true
trumpet
trunk
try
tub
tuffet
tug
tulip
tumble
tummy
tunnel
turkey
turn
turnip
twelve
twenty
twice
twig
twin
twist
two
type
typewriter
ugly
umbrella
uncle
under
underneath
undo
undress
uniform
union
unless
until
up
upon
upstairs
us
use
usual
usually

van
vase
vegetable
velvet
very
vest
vex
village
vinegar
violet
violin
visit
visitor
voice
wafer
wag
wait
wake
walk
wall
wander
want
war
wardrobe
warm
was
wash
wasp
waste
watch
water
wave
way
we
weak
wear
weather
web
wedding
Wednesday
weed
week
weigh
weight
well
wellingtons
west
wet
what
wheat
wheel
wheelbarrow
when
where
whether
whey
which
while
whip
whisker

whistle
white
Whitsun
who
whole
whose
why
wicked
wicket
wide
wife
wild
will
win
wind
windmill
window
wing
wink
winter
wipe
wire
wireless
wish
witch
with
wobble
wolf
woman
wonder
wood
woodwork
wooden
wool
word
work
world
worm
would
wrap
wriggle
wrist
write
wrong
yacht
yard
yawn
year
yellow
yes
yesterday
yet
yolk
you
young
your
yours
yourself
zebra
zip

zipper
zoo

APPENDIX 2: Forms Excluded from the Data Sample

aye	I'll	wouldn't
aren't	I'm	
ain't	I've	
baa	ice cream	
couldn't	isn't	
deck chair	jack-in-the-box	
didn't	jam jar	
don't	jam pot	
doesn't	lamp shade	
dressing table	Kitty	
farthing	letter box	
fir tree	living room	
fire engine	mantle piece	
fishing rod	mantle shelf	
fishing net	Miss	
gas stove	Mrs	
Guy Fawkes	Mr	
hadn't	nanny goat	
half penny	oh!	
half crown	shouldn't	
hasn't	thank you	
he's	three penny	
hey!	Union Jack	
hide-and-seek	upside-down	
hush	walkie-talkie	
I'd	won't	

APPENDIX 3: Specification of the Phonological Processes Included in the Study

(1) WI Cluster Reduction

pl-p, bl-b, pr-p, br-b, tr-t, dr-d, kr-k, gr-g, kl-k, gl-g, kw-k, fr-f, fl-f, θr-θ, sp-p, st-t, sk-k, sm-m, sn-n, sl-s, sw-s, spl-p, spr-p, skr-k, skw-k, str-t

(2) Stopping of fricatives and Affricates

f-p, v-b, θ-t, ʃ-d, s-t, z-d, ʃ-t, ʒ-d, tʃ-t, dʒ-d

(3) Fronting

k-t, g-d, ɲ-n

(4) Gliding of Liquids

l-w, l-j, r-w, r-j

(5) Prevocalic Voicing

p-b, t-d, k-g, f-v, θ-ð, ʃ-ʒ, s-z, tʃ-dʒ

(6) WF Devoicing

b-p, d-t, g-k, v-f, ð-θ, z-s, dʒ-tʃ

(7) Final Consonant Deletion

n-0, m-0, p-0, b-0, t-0, d-0, k-0, g-0, f-0, v-0, θ-0, ʃ-0, s-0, z-0, ʃ-0, ʒ-0, tʃ-0, dʒ-0

(8) Glottal Replacement

p-ʔ, t-ʔ, b-ʔ, d-ʔ, s-ʔ, z-ʔ, tʃ-ʔ, dʒ-ʔ

APPENDIX 4

Table 5.8: Results for Study 1

Phonological Processes	Floss-value	IMH
WI Cluster Reduction		
pl-p	3	
bl-b	4	
pr-p	1	
br-b	4	
tr-t	10	
dr-d	5	
kr-k	5	
kw-k	4	
kl-k	3	
gr-g	2	
gl-g	0	
fr-f	3	
fl-f	3	
θr-θ	0	
sp-p	4	
st-t	11	
sk-k	4	
sn-n	3	
sm-m	1	
sl-s	5	
sw-s	4	
spl-p	0	
spr-p	0	
skr-k	2	
skw-k	1	
str-t	3	
Stopping		
f-p all positions	16	2:1
SIWI	13	
SFWW	0	

SIWW	1	
SFWF	2	
v-b all positions	1	2:1
SIWI	1	
SFWW	0	
SIWW	0	
SFWF	0	
θ-t all positions	7	2:1
SIWI	6	
SFWW	0	
SIWW	0	
SFWF	1	
ø-d all positions	3	2:1
SIWI	3	
SFWW	0	
SIWW	0	
SFWF	0	
s-t all positions	24	2:1
SIWI	9	
SFWW	0	
SIWW	0	
SFWF	15	
z-d all positions	7	2:1
SIWI	2	
SFWW	0	
SIWW	2	
SFWF	3	
ʒ-t all positions	14	2:1
SIWI	9	
SFWW	0	
SIWW	0	
SFWF	5	
ʒ-d all positions	0	
SIWI	0	
SFWW	0	
SIWW	0	
SFWF	0	
tʒ-t all positions	15	2:1

SIWI	6	
SFWW	0	
SIWW	0	
SFWF	9	
d ₃ -d all positions	4	2:1
SIWI	2	
SFWW	0	
SIWW	0	
SFWF	2	
Fronting		
k-t all positions	43	2:1
SIWI	20	
SFWW	0	
SIWW	0	
SFWF	23	
g-d all positions	7	2:1
SIWI	3	
SFWW	0	
SIWW	0	
SFWF	3	
ŋ-n all posotions	3	2:1
SFWW	0	
SFWF	3	
Gliding		
l-w all positions	11	2:1
SIWI	11	
SFWW	0	
SIWW	0	
SFWF	0	
l-j all positions	5	2:1
SIWI	5	
SFWW	0	
SIWW	0	
SFWF	0	
r-w all positions	12	2:1
SIWI	12	

SIWW	0	
r-j all positions	0	
SIWI	0	
SIWW	0	
Prevocalic Voicing		
p-b all positions	20	2:1
SIWI	20	
SIWW	0	
t-d all positions	12	2:1
SIWI	10	
SIWW	2	
k-g all positions	11	2:1
SIWI	11	
SIWW	0	
f-v all positions	1	2:1
SIWI	1	
SIWW	0	
θ-ð all positions	0	
SIWI	0	
SIWW	0	
ʃ-ʒ all positions	0	
SIWI	0	
SFWF	0	
s-z all positions	0	
SIWI	0	
SIWW	0	
tʃ-dʒ all positions	0	
SIWI	0	
SIWW	0	
WF Devoicing		
b-p	1	
d-t	20	
g-k	6	
v-f	2	
ʧ-ʥ	0	
z-s	6	

dʒ-tʃ 0

Final Consonant Deletion

n-0	28	
m-0	10	
p-0	12	2:1
b-0	0	
t-0	37	2:1
d-0	24	
k-0	25	2:1
g-0	0	
f-0	7	
v-0	8	
θ-0	3	
ð-0	1	
s-0	23	2:1
z-0	10	
ʃ-0	0	
ʒ-0	0	
tʃ-0	6	
dʒ-0	4	

APPENDIX 5

Table 5.9: Rank Ordering of FLOSS-values for all Single Phonological Processes Studied in the SIWI Position

Rank	Phonological Process	FLOSS-value
1	Fronting k-t	20
1	PreVoi p-b	20
3	Stopping f-p	13
4	Gliding r-w	12
5	WI CR st-t	11
5	PreVoi k-g	11
5	Gliding l-w	11
8	WI CR tr-t	10
8	PreVoi t-d	10
10	Stopping s-t	9
10	Stopping ʃ-t	9
12	Stopping θ-t	6
12	Stopping tʃ-t	6
14	WI CR kr-k	5
14	WI CR dr-d	5
14	WI CR sl-s	5
14	Gliding l-j	5
18	WI CR br-b	4
18	WI CR bl-b	4
18	WI CR kw-k	4
18	WI CR sp-p	4
18	WI CR sk-k	4
18	WI CR sw-s	4
24	WI CR kl-k	3
24	WI CR fr-f	3
24	WI CR fl-f	3
24	WI CR sn-n	3
24	WI CR str-t	3
24	Fronting g-d	3
24	Stopping ʌ-d	3
24	WI CR pl-p	3
32	WI CR gr-g	2
32	WI CR skr-k	2

32	Stopping	z-d	2
32	Stopping	dʒ-d	2
36	WI CR	sm-m	1
36	WI CR	skw-k	1
36	WI CR	pl-p	1
36	Stopping	v-b	1
36	PreVoi	f-v	1
41	WI CR	gl-l	0
41	WI CR	θr-θ	0
41	WI CR	spl-p	0
41	WI CR	spr-p	0
41	Stopping	ʒ -d	0
41	PreVoi	θ -ʒ	0
41	PreVoi	s-z	0
41	PreVoi	tʃ-dʒ	0
41	Gliding	r-j	0

APPENDIX 6

Table 5.10: Rank Ordering of FLOSS-values for all Single Phonological Processes Studied in the SFWF position

Rank	Phonological Processes	FLOSS-value
1	F.C.D. t-0	37
2	F.C.D. n-0	28
3	F.C.D. k-0	25
4	F.C.D. d-0	24
5	F.C.D. s-0	23
5	Fronting k-t	23
7	WF Devoi d-t	20
8	Stopping s-t	15
9	F.C.D. p-0	12
10	F.C.D. z-0	10
10	F.C.D. m-0	10
12	Stopping tʃ-t	9
13	F.C.D. v-0	8
14	F.C.D. f-0	7
15	WF Devoi g-k	6
15	WF Devoi z-s	6
15	F.C.D. t-0	6
18	Stopping ʃ-t	5
19	F.C.D. dʒ-0	4
20	Fronting g-d	3
20	Fronting ɟ-n	3
20	Stopping z-d	3
20	F.C.D. θ-t	3
24	Stopping f-p	2
24	Stopping dʒ-d	2
24	WF Devoi v-f	2
27	F.C.D. ɰ-0	1
27	Stopping θ-t	1
27	WF Devoi b-p	1
30	Stopping v-b	0
30	Stopping θ-d	0
30	Stopping ɰ-d	0
30	Gliding l-w	0

30	Gliding	l-j	0
30	WF Devoi	ø - θ	0
30	WF DEvoi	d ₃ - t ₅	0
30	F.C.D.	ς - 0	0
30	F.C.D.	b - 0	0
30	F.C.D.	g - 0	0
30	F.C.D.	ʒ - 0	0

APPENDIX 7

Table 5.11: Rank Ordering of FLOSS-values for all Context-Independent Processes Operating in all Positions Simultaneously: Study 1

Rank	Phonological Processes	FLOSS-value	Additive - Not Additive
1	Fronting k-t	43	A
2	Stopping s-t	24	A
3	PreVoi p-b	20	A
4	Stopping f-p	16	A
5	Stopping tʃ-t	15	A
6	Stopping ʃ-t	14	A
7	Gliding r-w	12	A
8	Gliding l-w	11	A
8	PreVoi k-g	11	A
10	PreVoi t-d	10	A
11	Stopping θ-t	7	A
11	Stopping z-d	7	A
11	Fronting g-d	7	NA
14	Gliding l-j	5	A
15	Stopping dʒ-d	4	A
16	Fronting ŋ-n	3	A
16	Stopping ʒ-d	3	A
18	Stopping v-b	1	A
18	PreVoi f-v	1	A
20	Stopping ʒ-d	0	A
20	Gliding r-j	0	A
20	PreVoi θ-ʒ	0	A
20	PreVoi s-z	0	A
20	PreVoi t-d	0	A

Appendix 8: Results for Study 2

Process Combinations	Homoph. Forms	Homoph. Types	Homoph. Pairs	IMH
<hr/>				
(A) Same Place in Structure				
(1) Complete Feeding				
(a) SIWI - Altered PS				
pl-p;p-b	22	45	24	2.06:1
tr-t;t-d	15	33	21	2.20:1
kr-k;k-t	26	53	28	2.04:1
kr-k;k-g	17	35	19	2.06:1
kl-k;k-t	22	45	24	2.05:1
kl-k;k-g	15	30	15	2.00:1
kw-k;k-t	21	45	27	2.14:1
kw-k;k-g	13	26	13	2.00:1
gr-g;g-d	5	11	7	2.20:1
gl-g;g-d	5	10	5	2.00:1
fr-f;f-p	18	36	18	2.00:1
fr-f;f-v	4	8	4	2.00:1
fl-f;f-p	15	32	19	2.13:1
fl-f;f-v	4	8	4	2.00:1
θr-θ;θ-t	6	12	6	2.00:1
θr-θ;θ-θ	1	2	1	2.00:1
sp-p;p-b	29	61	35	2.10:1
st-t;t-d	23	50	31	2.17:1
sk-k;k-t	24	49	26	2.04:1
sl-s;s-t	14	29	16	2.07:1
sl-s;s-z	5	10	5	2.00:1
sw-s;s-t	12	24	12	2.00:1
sw-s;s-z	3	6	3	2.00:1
spl-p;p-b	20	40	20	2.00:1
spr-p;p-b	20	40	20	2.00:1
skr-k;k-t	23	46	23	2.00:1
skr-k;k-g	13	26	13	2.00:1
skw-k;k-t	20	41	22	2.05:1

skw-k;k-g	13	26	13	2.00:1
str-t;t-d	14	29	16	2.07:1
s-t;t-d	22	44	22	2.00:1

(b) SIWI - Unaltered PS

f-p;p-b	40	86	52	2.15:1
f-v;v-b	21	42	21	2.00:1
θ-t;t-d	17	34	17	2.00:1
θ-ϑ;ϑ-d	4	8	4	2.00:1
s-z;z-d	5	10	5	2.00:1
ς-t;t-d	19	41	25	2.16:1
tς-t;t-d	17	36	21	2.12:1
tς-d ₃ ;d ₃ -d	7	14	7	2.00:1
k-t;t-d	29	62	37	2.14:1
k-g;g-d	25	50	25	2.00:1

(c) SFWF - Altered PS

k-t;t-0	71	150	87	2.11:1
g-d;d-0	27	54	27	2.00:1
g-d;d-t	31	64	35	2.07:1
θ-t;t-0	41	82	41	2.00:1
ϑ-d;d-t	20	40	20	2.00:1
ϑ-d;d-0	25	50	25	2.00:1
s-t;t-0	72	151	86	2.10:1
z-d;d-0	36	73	38	2.03:1
z-d;d-t	26	54	30	2.08:1
ς-t;t-0	42	84	42	2.00:1
ζ-d;d-0	24	48	24	2.00:1
ζ-d;d-t	20	40	20	2.00:1
tς-t;t-0	50	101	52	2.02:1
d ₃ -d;d-0	30	60	30	2.00:1
d ₃ -d;d-t	24	49	26	2.04:1

(d) SFWF - Unaltered PS

b-p;p-0	13	26	13	2.00:1
---------	----	----	----	--------

d-t;t-0	67	141	81	2.10:1
g-k;k-t	33	70	41	2.12:1
g-k;k-0	31	62	31	2.00:1
v-b;b-p	5	10	5	2.00:1
v-f;f-p	8	16	8	2.00:1
v-b;b-0	8	16	8	2.00:1
v-f;f-0	17	34	17	2.00:1
f-p;p-0	19	39	21	2.05:1
z-s;s-t	25	51	27	2.04:1
z-s;s-0	37	75	39	2.03:1
ʔ-θ;θ-t	1	2	1	2.00:1
ʔ-θ;θ-0	4	8	4	2.00:1
ɲ-n;n-0	36	72	36	2.00:1
dʒ-tʃ-tʃ-t	13	26	13	2.00:1
dʒ-tʃ-tʃ-0	10	20	10	2.00:1
θ-t;t-ʔ	1	2	1	2.00:1
ʔ-d;d-ʔ	0	0	0	---
ʃ-t;t-ʔ	5	10	5	2.00:1
ʒ-d;d-ʔ	0	0	0	2.00:1
k-t;t-ʔ	23	46	23	2.00:1
g-d;d-ʔ	3	6	3	2.00:1
b-p;p-ʔ	1	2	1	2.00:1
d-t;t-ʔ	20	40	20	2.00:1
s-t;t-ʔ	15	30	15	2.00:1
tʃ-t;t-ʔ	9	18	9	2.00:1
dʒ-d;d-ʔ	2	4	2	2.00:1
z-s;s-ʔ	6	12	6	2.00:1
dʒ-tʃ;tʃ-ʔ	0	0	0	---

(2) Incomplete Feeding

(a) SIWI - Unaltered PS

f-p;pl-p	18	39	25	2.17:1
p-b;bl-b	25	52	29	2.08:1
p-b;br-b	24	48	24	2.00:1
θ-t;tr-t	14	31	20	2.21:1
ʃ-t;tr-t	16	36	24	2.25:1
k-t;tr-t	35	77	49	2.20:1
g-d;dr-d	10	23	16	2.30:1

t-d;dr-d	20	46	37	2.30:1
k-g;gr-g	18	39	24	2.17:1
k-g;gl-g	14	28	14	2.00:1
f-p;sp-p	21	43	23	2.05:1
k-t;st-t	32	76	57	2.38:1

(b) SIWI - Counter Feeding to Unaltered PS

pl-p;f-p	15	31	17	2.07:1
bl-b;p-b	23	47	25	2.04:1
br-b;p-b	24	48	24	2.00:1
tr-t;θ-t	12	25	14	2.08:1
tr-t;∫-t	16	35	22	2.19:1
tr-t;k-t	27	57	33	2.11:1
dr-d;g-d	8	17	10	2.13:1
dr-d;t-d	11	25	17	2.27:1
gr-g;k-g	12	24	12	2.00:1
sp-p;f-p	21	43	23	2.05:1
st-t;k-t	27	62	43	2.30:1
gl-g;k-g	10	20	10	2.00:1

(d) SIWI - Type1IF

sp-p;pl-p	8	16	8	2.00:1
sp-p;pr-p	5	10	5	2.00:1
st-t;tr-t	20	44	28	2.20:1
sk-k;kr-k	13	26	13	2.00:1
sk-k;kw-k	7	15	9	2.14:1
sk-k;kl-k	7	14	7	2.00:1

(e) SIWI - Counter Feeding Type1IF

pl-p;sp-p	8	16	8	2.00:1
pr-p;sp-p	5	10	5	2.00:1
tr-t;st-t	16	34	20	2.13:1
kr-k;sk-k	10	20	10	2.00:1
kw-k;sk-k	6	12	6	2.00:1
kl-k;sk-k	7	14	7	2.00:1

(f) SFWF - Type1IF

θ-t;k-t	25	53	27	2.12:1
---------	----	----	----	--------

(g) SFWF - Counter Feeding Type1IF

k-t;θ-t	25	53	27	2.12:1
---------	----	----	----	--------

(h) SIWI - Type2IF

tr-t;s-t	20	42	24	2.10:1
----------	----	----	----	--------

k-t;s-t	33	70	41	2.12:1
---------	----	----	----	--------

(i) SIWI - Counter Feeding Type2IF

s-t;tr-t	17	36	21	2.11:1
----------	----	----	----	--------

s-t;k-t	29	62	37	2.14:1
---------	----	----	----	--------

(j) SFWF - Type2IF

θ-t;s-t	16	33	18	2.06:1
---------	----	----	----	--------

s-t;k-t	42	87	48	2.07:1
---------	----	----	----	--------

(k) SFWF - Counter Feeding Type2IF

s-t;θ-t	16	33	18	2.06:1
---------	----	----	----	--------

k-t;s-t	42	87	48	2.07:1
---------	----	----	----	--------

(l) SIWI - Type3IF

st-t;r-j	11	22	11	2.00:1
----------	----	----	----	--------

sp-p;r-j	4	8	4	2.00:1
----------	---	---	---	--------

sp-p;l-j	9	18	9	2.00:1
----------	---	----	---	--------

sk-k;r-j	4	8	4	2.00:1
----------	---	---	---	--------

r-j;k-t	21	42	21	2.00:1
---------	----	----	----	--------

r-j;g-d	3	6	3	2.00:1
---------	---	---	---	--------

r-w;g-d	15	30	15	2.00:1
---------	----	----	----	--------

l-j;g-d	8	16	8	2.00:1
---------	---	----	---	--------

l-w;g-d	16	32	16	2.00:1
---------	----	----	----	--------

r-j;f-p	13	26	13	2.00:1
---------	----	----	----	--------

l-j;f-p	17	34	17	2.00:1
---------	----	----	----	--------

r-j;θ-t	3	6	3	2.00:1
---------	---	---	---	--------

r-w;θ-t	18	36	18	2.00:1
---------	----	----	----	--------

(m) SIWI - Counter Feeding Type3IF

r-j;s-t	11	22	11	2.00:1
---------	----	----	----	--------

l-j;sp-p	9	18	9	2.00:1
----------	---	----	---	--------

r-j;sp-p	4	8	4	2.00:1
r-j;sk-k	4	8	4	2.00:1
k-t;r-j	21	42	21	2.00:1
g-d;r-w	15	30	15	2.00:1
g-d;r-j	3	6	3	2.00:1
g-d;l-w	16	32	16	2.00:1
g-d;l-j	8	16	8	2.00:1
f-p;r-j	13	26	13	2.00:1
f-p;l-j	17	34	17	2.00:1
θ-t;r-j	3	6	3	2.00:1
θ-t;r-w	18	36	18	2.00:1

(n) SFWF - Type3IF

θ-t;f-p	3	6	3	2.00:1
f-p;t-0	40	80	40	2.00:1
f-p;m-0	13	26	13	2.00:1
θ-t;p-0	13	26	13	2.00:1
s-t;p-0	29	58	29	2.00:1
s-t;k-0	39	80	45	2.05:1
η-n;s-0	27	54	27	2.00:1
η-n;t-0	40	80	40	2.00:1
k-t;s-0	48	103	62	2.15:1
θ-t;k-0	26	52	26	2.00:1

(o) SFWF - Counter Feeding Type3IF

f-p;θ-t	3	6	3	2.00:1
t-0;f-p	40	80	40	2.00:1
m-0;f-p	13	26	13	2.00:1
p-0;θ-t	13	26	13	2.00:1
p-0;s-t	29	58	29	2.00:1
k-0;s-t	39	80	45	2.05:1
s-0;η-n	27	54	27	2.00:1
t-0;η-n	40	80	40	2.00:1
s-0;k-t	48	103	62	2.15:1
k-0;θ-t	26	52	26	2.00:1

(p) SIWI - Type3+4IF

l-j;p-b	25	50	25	2.00:1
---------	----	----	----	--------

r-j;p-b	20	40	20	2.00:1
r-j;t-d	10	20	10	2.00:1
r-j;k-g	11	22	11	2.00:1
r-w;k-g	24	48	24	2.00:1
l-j;k-g	17	34	17	2.00:1
l-w;k-g	24	48	24	2.00:1
l-w;k-t	33	66	33	2.00:1
r-w;k-t	28	57	30	2.03:1
l-j;s-t	14	28	14	2.00:1

(q) SIWI - Counter Feeding Type3+4IF

p-b;l-j	25	50	25	2.00:1
p-b;r-j	20	40	20	2.00:1
t-d;r-j	10	20	10	2.00:1
k-g;r-j	11	22	11	2.00:1
k-g;r-w	24	48	24	2.00:1
k-g;l-j	17	34	17	2.00:1
k-g;l-w	24	48	24	2.00:1
k-t;l-w	33	66	33	2.00:1
s-t;l-j	14	28	14	2.00:1

(r) SIWI - Type4(i)IF

sp-p;r-w	16	32	16	2.00:1
sp-p;l-w	17	34	17	2.00:1
sk-k;r-w	16	32	16	2.00:1
r-w;s-t	21	42	21	2.00:1
r-j;s-t	9	18	9	2.00:1

(s) SFWF - Type4(i)IF

j-n;s-t	18	36	18	2.00:1
---------	----	----	----	--------

(3) Conspiring

(a) SIWI - Unaltered PS

bl-b;br-b	8	16	8	2.00:1
kr-k;kl-k	10	20	10	2.00:1
kr-k;kw-k	10	20	10	2.00:1
kr-k;skw-k	6	12	6	2.00:1
gr-g;gl-g	12	24	12	2.00:1

kl-k;kw-k	9	18	9	2.00:1
kl-k;skr-k	6	12	6	2.00:1
kl-k;skw-k	4	8	4	2.00:1
kw-k;skr-k	6	12	6	2.00:1
fr-f;fl-f	8	16	8	2.00:1
sl-s;sw-s	7	14	7	2.00:1
spl-p;spr-p	0	0	0	---
skr-k;skw-k	3	6	3	2.00:1
θ-t;s-t	18	37	20	2.06:1
θ-t;ś-t	15	31	17	2.07:1
θ-t;tś-t	10	22	14	2.20:1
ʎ-d;z-d	5	10	5	2.00:1
ʎ-d;ʒ-d	3	6	3	2.00:1
ʎ-d;dʒ-d	5	19	5	2.00:1
s-t;ś-t	21	45	27	2.14:1
s-t;tś-t	16	33	18	2.06:1
z-d;ʒ-d	2	4	2	2.00:1
z-d;dʒ-d	4	8	4	2.00:1
ś-t;tś-t	12	27	18	2.25:1
ʒ-d;dʒ-d	2	4	2	2.00:1
l-w;r-w	27	58	35	2.15:1
l-j;r-j	19	38	19	2.00:1
bl-b;v-b	5	10	5	2.00:1
br-b;v-b	5	10	5	2.00:1
tr-t;tś-t	17	36	21	2.12:1
dr-d;ð-d	8	16	8	2.00:1
dr-d;z-d	6	13	8	2.17:1
dr-d;ʒ-d	5	10	5	2.00:1
dr-d;dʒ-d	7	14	7	2.00:1
st-t;θ-t	17	35	19	2.06:1
st-t;ś-t	20	42	24	2.10:1
st-t;tś-t	13	30	21	2.31:1
st-t;s-t	24	50	28	2.08:1
spl-p;f-p	13	26	13	2.00:1
spr-p;f-p	13	26	13	2.00:1
str-t;θ-t	10	20	10	2.00:1
str-t;s-t	16	32	16	2.00:1
str-t;ś-t	12	25	14	2.00:1

str-t;tʃ-t	9	19	11	2.11:1
str-t;k-t	23	47	25	2.04:1
v-b;p-b	22	44	22	2.00:1
θ-t;k-t	28	57	30	2.04:1
ʃ-d;g-d	8	16	8	2.00:1
ʃ-d;t-d	13	27	15	2.08:1
z-d;g-d	5	10	5	2.00:1
z-d;t-d	10	22	14	2.20:1
ʃ-t;k-t	32	68	40	2.13:1
ʒ-d;g-d	3	6	3	2.00:1
ʒ-d;t-d	10	20	10	2.00:1
tʃ-t;k-t	25	54	33	2.16:1
dʒ-d;g-d	7	14	7	2.00:1
dʒ-d;t-d	14	28	14	2.00:1

(b) SIWI - Altered PS

spl-p;pl-p	3	6	3	2.00:1
spr-p;pr-p	1	2	1	2.00:1
str-t;tr-t	8	18	12	2.25:1
skr-k;kr-k	8	16	8	2.00:1
skw-k;kw-k	3	6	3	2.00:1
spl-p;sp-p	4	8	4	2.00:1
spr-p;sp-p	4	8	4	2.00:1
str-t;st-t	15	30	15	2.00:1
skr-k;sk-k	5	10	5	2.00:1
skw-k;sk-k	5	10	5	2.00:1

(d) SFWF - Unaltered PS

θ-t;ʃ-t	7	14	7	2.00:1
θ-t;tʃ-t	11	22	11	2.00:1
ʃ-d;z-d	3	6	3	2.00:1
ʃ-d;ʒ-d	0	0	0	---
s-t;ʃ-t	18	38	22	2.11:1
s-t;tʃ-t	24	48	24	2.00:1
z-d;ʒ-d	3	6	3	2.00:1
z-d;dʒ-d	6	12	6	2.00:1
ʃ-t;tʃ-t	15	31	17	2.07:1
ʒ-d;dʒ-d	2	4	2	2.00:1

n-0;m-0	41	82	41	2.00:1
n-0;p-0	47	95	49	2.02:1
n-0;b-0	32	64	32	2.00:1
n-0;t-0	76	161	94	2.12:1
n-0;d-0	56	136	86	2.43:1
n-0;k-0	58	124	74	2.21:1
n-0;g-0	36	72	36	2.00:1
n-0;f-0	40	80	40	2.00:1
n-0;v-0	41	83	43	2.02:1
n-0;θ-0	30	62	34	2.07:1
n-0;ϑ-0	29	58	29	2.00:1
n-0;s-0	58	120	66	2.07:1
n-0;z-0	41	83	43	2.02:1
n-0;ς-0	32	64	32	2.00:1
n-0;ζ-0	28	56	28	2.00:1
n-0;τς-0	39	79	41	2.03:1
n-0;dζ-0	33	67	35	2.03:1
m-0;p-0	26	54	30	2.08:1
m-0;b-0	10	20	10	2.00:1
m-0;t-0	57	116	61	2.04:1
m-0;d-0	39	79	41	2.03:1
m-0;k-0	39	81	45	2.08:1
m-0;g-0	13	26	13	2.00:1
m-0;f-0	19	38	19	2.00:1
m-0:v-0	19	39	21	2.05:1
m-0;θ-0	13	26	13	2.00:1
m-0;ϑ-0	11	22	11	2.00:1
m-0;s-0	35	70	35	2.00:1
m-0;z-0	23	46	23	2.00:1
m-0;ς-0	11	22	11	2.00:1
m-0;ζ-0	10	20	10	2.00:1
m-0;τς-0	21	43	23	2.05:1
m-0;dζ-0	15	30	15	2.00:1
p-0;b-0	13	26	13	2.00:1
p-0;t-0	58	119	64	2.05:1
p-0;d-0	38	78	42	2.05:1

p-0;k-0	47	94	47	2.00:1
p-0;g-0	16	32	16	2.00:1
p-0;f-0	19	39	21	2.05:1
p-0;v-0	24	48	24	2.00:1
p-0;θ-0	16	32	16	2.00:1
p-0;ϑ-0	13	26	13	2.00:1
p-0;s-0	38	77	40	2.03:1
p-0;z-0	22	46	26	2.10:1
p-0;ς-0	15	30	15	2.00:1
p-0;ζ-0	12	24	12	2.00:1
p-0;tς-0	23	46	23	2.00:1
p-0;dζ-0	17	34	17	2.00:1
b-0;t-0	41	82	41	2.00:1
b-0;d-0	25	50	25	2.00:1
b-0;k-0	29	58	29	2.00:1
b-0;g-0	3	6	3	2.00:1
b-0;f-0	8	16	8	2.00:1
b-0;v-0	8	16	8	2.00:1
b-0;θ-0	3	6	3	2.00:1
b-0;ϑ-0	1	2	1	2.00:1
b-0;s-0	23	46	23	2.00:1
b-0;z-0	10	20	10	2.00:1
b-0;ς-0	2	4	2	2.00:1
b-0;ζ-0	0	0	0	---
b-0;tς-0	7	14	7	2.00:1
b-0;dζ-0	4	8	4	2.00:1
t-0;d-0	67	141	81	2.10:1
t-0;k-0	71	150	87	2.11:1
t-0;g-0	49	98	49	2.00:1
t-0;f-0	47	96	51	2.04:1
t-0;v-0	45	93	51	2.07:1
t-0;θ-0	41	82	41	2.00:1
t-0;ϑ-0	38	76	38	2.00:1
t-0;s-0	72	151	86	2.10:1
t-0;z-0	49	100	53	2.04:1
t-0;ς-0	42	84	42	2.00:1
t-0;ζ-0	37	74	37	2.00:1
t-0;tς-0	50	101	52	2.02:1

t-0;d ₃ -0	45	90	45	2.00:1
d-0;k-0	57	118	65	2.07:1
d-0;g-0	27	54	27	2.00:1
d-0;f-0	32	67	38	2.09:1
d-0;v-0	34	69	36	2.03:1
d-0;θ-0	28	56	28	2.00:1
d-0;ϑ-0	25	50	25	2.00:1
d-0;s-0	53	106	53	2.00:1
d-0;z-0	36	73	38	2.03:1
d-0;ς-0	25	50	25	2.00:1
d-0;ζ-0	24	48	24	2.00:1
d-0;τ-0	33	67	35	2.03:1
d-0;d ₃ -0	30	60	30	2.00:1
k-0;g-0	31	62	31	2.00:1
k-0;f-0	33	66	33	2.00:1
k-0;v-0	35	72	39	2.06:1
k-0;θ-0	29	59	51	2.03:1
k-0;ϑ-0	27	54	27	2.00:1
k-0;s-0	52	107	58	2.06:1
k-0;z-0	40	80	40	2.00:1
k-0;ς-0	28	56	28	2.00:1
k-0;ζ-0	25	50	25	2.00:1
k-0;τ-0	34	70	38	2.06:1
k-0;d ₃ -0	32	64	32	2.00:1
g-0;f-0	9	18	9	2.00:1
g-0;v-0	8	16	8	2.00:1
g-0;θ-0	3	6	3	2.00:1
g-0;ϑ-0	1	2	1	2.00:1
g-0;s-0	23	46	23	2.00:1
g-0;z-0	11	22	11	2.00:1
g-0;ς-0	3	6	3	2.00:1
g-0;ζ-0	0	0	0	---
g-0;τ-0	9	18	9	2.00:1
g-0;d ₃ -0	6	12	6	2.00:1
f-0;v-0	17	34	17	2.00:1
f-0;θ-0	10	20	10	2.00:1
f-0;ϑ-0	8	16	8	2.00:1
f-0;s-0	33	66	33	2.00:1

f-0;z-0	18	36	18	2.00:1
f-0;ʃ-0	8	16	8	2.00:1
f-0;ʒ-0	7	14	7	2.00:1
f-0;tʃ-0	14	28	14	2.00:1
f-0;dʒ-0	12	24	12	2.00:1
v-0;θ-0	11	22	11	2.00:1
v-0;ð-0	9	18	9	2.00:1
v-0;s-0	31	63	33	2.03:1
v-0;z-0	18	36	18	2.00:1
v-0;ʃ-0	8	16	8	2.00:1
v-0;ʒ-0	8	16	8	2.00:1
v-0;tʃ-0	15	30	15	2.00:1
v-0;dʒ-0	13	26	13	2.00:1
θ-0;ʃ-0	4	8	4	2.00:1
θ-0;s-0	28	56	28	2.00:1
θ-0;z-0	13	26	13	2.00:1
θ-0;ʃ-0	4	8	4	2.00:1
θ-0;ʒ-0	3	6	3	2.00:1
θ-0;tʃ-0	10	20	10	2.00:1
θ-0;dʒ-0	7	14	7	2.00:1
ð-0;s-0	24	48	24	2.00:1
ð-0;z-0	11	22	11	2.00:1
ð-0;ʃ-0	1	2	1	2.00:1
ð-0;ʒ-0	1	2	1	2.00:1
ð-0;tʃ-0	7	14	7	2.00:1
ð-0;dʒ-0	5	10	5	2.00:1
s-0;z-0	37	75	39	2.03:1
s-0;ʃ-0	25	50	25	2.00:1
s-0;ʒ-0	23	46	23	2.00:1
s-0;tʃ-0	29	58	29	2.00:1
s-0;dʒ-0	28	56	28	2.00:1
z-0;ʃ-0	11	22	11	2.00:1
z-0;ʒ-0	10	20	10	2.00:1
z-0;tʃ-0	16	32	16	2.00:1
z-0;dʒ-0	14	28	14	2.00:1
ʃ-0;ʒ-0	0	0	0	---
ʃ-0;tʃ-0	9	18	9	2.00:1
ʃ-0;dʒ-0	4	8	4	2.00:1

ʒ-0;ts-0	6	12	6	2.00:1
ʒ-0;dʒ-0	4	8	4	2.00:1
ts-0;dʒ-0	10	20	10	2.00:1
f-p;b-p	4	8	4	2.00:1
θ-t;k-t	25	51	27	2.04:1
θ-t;d-t	22	44	22	2.00:1
ʃ-d;g-d	3	6	3	2.00:1
ʃ-t;k-t	31	62	31	2.00:1
ʃ-t;d-t	24	49	26	2.04:1
z-d;g-d	7	14	7	2.00:1
ʒ-d;g-d	3	6	3	2.00:1
ts-t;k-t	33	69	39	2.09:1
ts-t;d-t	30	62	34	2.07:1
dʒ-d;g-d	5	11	7	2.20:1
k-t;d-t	49	103	59	2.10:1
p-ʔ;b-ʔ	1	2	1	2.00:1
p-ʔ;t-ʔ	15	30	15	2.00:1
p-ʔ;d-ʔ	6	12	6	2.00:1
p-ʔ;s-ʔ	4	8	4	2.00:1
p-ʔ;z-ʔ	4	8	4	2.00:1
p-ʔ;ts-ʔ	5	10	5	2.00:1
p-ʔ;dʒ-ʔ	1	2	1	2.00:1
b-ʔ;t-ʔ	4	8	4	2.00:1
b-ʔ;d-ʔ	1	2	1	2.00:1
b-ʔ;s-ʔ	0	0	0	---
b-ʔ;z-ʔ	0	0	0	---
b-ʔ;ts-ʔ	1	2	1	2.00:1
b-ʔ;dʒ-ʔ	0	0	0	2.00:1
t-ʔ;d-ʔ	20	40	20	2.00:1
t-ʔ;s-ʔ	15	30	15	2.00:1
t-ʔ;z-ʔ	6	12	6	2.00:1
t-ʔ;ts-ʔ	9	18	9	2.00:1
t-ʔ;dʒ-ʔ	4	8	4	2.00:1
d-ʔ;s-ʔ	6	12	6	2.00:1
d-ʔ;z-ʔ	4	8	4	2.00:1
d-ʔ;ts-ʔ	5	10	5	2.00:1
d-ʔ;dʒ-ʔ	2	4	2	2.00:1
s-ʔ;z-ʔ	6	12	6	2.00:1

s-l;t -l	0	0	0	2.00:1
s-l;d -l	1	2	1	2.00:1
z-l;t -l	0	0	0	---
z-l;d -l	0	0	0	---
tʃ-l;d -l	0	0	0	---

(B) Different Place in Structure

(1) SIWI: Context Independent Processes

SFWF: Context Independent Processes

(a) SIWI:HIGH SFWF:HIGH

SIWI	SFWF				
k-t	k-t	43	86	43	2.00:1
k-t	s-t	38	76	38	2.00:1
k-t	tʃ-t	30	60	30	2.00:1
l-w	k-t	29	62	38	2.14:1
l-w	s-t	26	53	28	2.04:1
l-w	tʃ-t	21	43	23	2.05:1
f-p	k-t	35	72	39	2.06:1
f-p	s-t	28	57	30	2.04:1
f-p	t -t	22	45	24	2.05:1

(b) SIWI:HIGH SFWF:LOW

k-t	ŋ-n	25	50	25	2.00:1
k-t	ʃ-d	20	40	20	2.00:1
k-t	l-j	20	40	20	2.00:1
l-w	ŋ-n	14	24	14	2.00:1
l-w	ʃ-d	11	22	11	2.00:1
l-w	l-j	11	22	11	2.00:1
f-p	ŋ-n	16	32	16	2.00:1
f-p	ʃ-d	13	26	13	2.00:1
f-p	l-j	13	26	13	2.00:1

(c) SIWI:LOW SFWF:HIGH

z-d	k-t	23	46	23	2.00:1
z-d	s-t	15	30	15	2.00:1
z-d	tʃ-t	9	18	9	2.00:1
r-j	k-t	24	48	24	2.00:1
r-j	s-t	16	32	16	2.00:1

r-j	tʃ-t	9	18	9	2.00:1
v-b	k-t	24	48	24	2.00:1
v-b	s-t	16	32	16	2.00:1
v-b	tʃ-t	10	20	10	2.00:1

(d) SIWI:LOW SFWF:LOW

z-d	ʃ-n	3	6	3	2.00:1
z-d	ʒ-d	0	0	0	---
z-d	l-j	0	0	0	---
r-j	ʃ-n	4	8	4	2.00:1
r-j	ʒ-d	0	0	0	---
r-j	l-j	0	0	0	---
v-b	ʃ-n	4	8	4	2.00:1
v-b	ʒ-d	1	2	1	2.00:1
v-b	l-j	1	2	1	2.00:1

(2) SIWI: Context Independent Processes

SFWF: Context Dependent Processes - Substitution

(a) SIWI:HIGH SFWF:HIGH

k-t	d-t	40	81	42	2.03:1
k-t	g-k	26	53	28	2.04:1
k-t	z-s	26	52	26	2.00:1
l-w	d-t	29	60	33	2.07:1
l-w	g-k	17	34	17	2.00:1
l-w	z-s	17	34	17	2.00:1
f-p	d-t	32	65	34	2.03:1
f-p	g-k	20	40	20	2.00:1
f-p	z-s	19	38	19	2.00:1

(b) SIWI:HIGH SFWF:LOW

k-t	dʒ-tʃ	20	40	20	2.00:1
k-t	ʒ-θ	20	40	20	2.00:1
k-t	b-p	23	46	23	2.00:1
l-w	dʒ-tʃ	11	22	11	2.00:1
l-w	ʒ-θ	11	22	11	2.00:1
l-w	b-p	12	24	12	2.00:1
f-p	dʒ-tʃ	13	26	13	2.00:1
f-p	ʒ-θ	13	26	13	2.00:1

f-p	b-p	14	28	14	2.00:1
-----	-----	----	----	----	--------

(c) SIWI:LOW SFWF:HIGH

z-d	d-t	20	40	20	2.00:1
z-d	g-k	6	12	6	2.00:1
z-d	z-s	6	12	6	2.00:1
r-j	d-t	22	44	22	2.00:1
r-j	g-k	6	12	6	2.00:1
r-j	z-s	6	12	6	2.00:1
v-b	d-t	21	42	21	2.00:1
v-b	g-k	7	14	7	2.00:1
v-b	z-s	7	14	7	2.00:1

(d) SIWI:LOW SFWF:LOW

z-d	d ₃ -t ₃	0	0	0	---
z-d	ø-ø	0	0	0	---
z-d	b-p	1	2	1	2.00:1
r-j	d ₃ -t ₃	0	0	0	---
r-j	ø-ø	0	0	0	---
r-j	b-p	1	2	1	2.00:1
v-b	d ₃ -t ₃	1	2	1	2.00:1
v-b	ø-ø	1	2	1	2.00:1
v-b	b-p	2	4	2	2.00:1

(3) SIWI: Context Independent Processes

SFWF: Context Dependent Processes - Deletion

(a) SIWI:HIGH SFWF:HIGH

k-t	t-0	58	118	62	2.03:1
k-t	n-0	49	99	51	2.02:1
k-t	k-0	47	94	47	2.00:1
l-w	t-0	44	92	54	2.09:1
l-w	n-0	40	83	46	2.08:1
l-w	k-0	32	67	45	2.09:1
f-p	t-0	54	110	58	2.04:1
f-p	n-0	39	80	43	2.05:1
f-p	k-0	38	78	42	2.05:1

(b) SIWI:HIGH SFWF:LOW

k-t	b-0	20	40	20	2.00:1
k-t	ǵ-0	21	42	21	2.00:1
k-t	ſ-0	20	40	20	2.00:1
l-w	b-0	11	22	11	2.00:1
l-w	ǵ-0	12	24	12	2.00:1
l-w	ſ-0	11	22	11	2.00:1
f-p	b-0	13	26	13	2.00:1
f-p	ǵ-0	14	28	14	2.00:1
f-p	ſ-0	14	28	14	2.00:1

(c) SIWI:LOW SFWF:HIGH

z-d	t-0	37	74	37	2.00:1
z-d	n-0	28	56	28	2.00:1
z-d	k-0	25	50	25	2.00:1
r-j	t-0	39	78	39	2.00:1
r-j	n-0	28	56	28	2.00:1
r-j	k-0	26	52	26	2.00:1
v-b	t-0	38	76	38	2.00:1
v-b	n-0	29	58	29	2.00:1
v-b	k-0	26	52	26	2.00:1

(d) SIWI:LOW SFWF:LOW

z-d	b-0	0	0	0	---
z-d	ǵ-0	1	2	1	2.00:1
z-d	ſ-0	0	0	0	---
r-j	b-0	0	0	0	---
r-j	ǵ-0	1	2	1	2.00:1
r-j	ſ-0	0	0	0	---
v-b	b-0	1	2	1	2.00:1
v-b	ǵ-0	2	4	2	2.00:1
v-b	ſ-0	1	2	1	2.00:1

(4) SIWI: Context Dependent

SFWF: Context Dependent - Substitution

(a) SIWI:HIGH SFWF:HIGH

st-t	d-t	31	62	31	2.00:1
st-t	g-k	16	33	18	2.06:1
st-t	z-s	17	34	17	2.00:1

tr-t d-t	30	60	30	2.00:1
tr-t g-k	16	33	18	2.06:1
tr-t z-s	16	32	16	2.00:1
dr-d d-t	25	50	25	2.00:1
dr-d g-k	11	22	11	2.00:1
dr-d z-s	11	22	11	2.00:1

(b) SIWI:HIGH SFWF:LOW

st-t d ₃ -t ₅	11	22	11	2.00:1
st-t ø-ø	11	22	11	2.00:1
st-t b-p	12	24	12	2.00:1
tr-t d ₃ -t ₅	10	20	10	2.00:1
tr-t ø-ø	10	20	10	2.00:1
tr-t b-p	11	22	11	2.00:1
dr-d d ₃ -t ₅	5	10	5	2.00:1
dr-d ø-ø	5	10	5	2.00:1
dr-d b-p	6	12	6	2.00:1

(c) SIWI:LOW SFWF:HIGH

ør-ø d-t	20	40	20	2.00:1
ør-ø g-k	6	12	6	2.00:1
ør-ø z-s	6	12	6	2.00:1
spl-p d-t	20	40	20	2.00:1
spl-p g-k	6	12	6	2.00:1
spl-z z-s	6	12	6	2.00:1
pr-p d-t	21	42	21	2.00:1
pr-p g-k	7	14	7	2.00:1
pr-p z-s	7	14	7	2.00:1

(d) SIWI:LOW SFWF:LOW

ør-ø d ₃ -t ₅	0	0	0	---
ør-ø ø-ø	0	0	0	---
ør-ø b-p	1	2	1	2.00:1
spl-p d ₃ -t ₅	0	0	0	---
spl-p ø-ø	0	0	0	---
spl-p b-p	1	2	1	2.00:1
pr-p d ₃ -t ₅	1	2	1	2.00:1
pr-p ø-ø	1	2	1	2.00:1

pr-p	b-p	2	4	2	2.00:1
------	-----	---	---	---	--------

(5) SIWI: Context Dependent

SFWF: Context Dependent - Deletion

(a) SIWI:HIGH SFWF:HIGH

st-t	t-0	46	95	53	2.07:1
st-t	n-0	41	82	41	2.00:1
st-t	k-0	36	73	38	2.03:1
tr-t	t-0	48	97	50	2.02:1
tr-t	n-0	39	78	39	2.00:1
tr-t	k-0	36	73	38	2.03:1
dr-d	t-0	42	84	42	2.00:1
dr-d	n-0	34	69	36	2.03:1
dr-d	k-0	31	62	31	2.00:1

(b) SIWI:HIGH SFWF:LOW

st-t	b-0	11	22	11	2.00:1
st-t	q-0	12	24	12	2.00:1
st-t	∫-0	11	22	11	2.00:1
tr-t	b-0	10	20	10	2.00:1
tr-t	ø-0	11	22	11	2.00:1
tr-t	∫-0	10	20	10	2.00:1
dr-d	b-0	5	10	5	2.00:1
dr-d	ø-0	6	12	6	2.00:1
dr-d	∫-0	5	10	5	2.00:1

(c) SIWI:LOW SFWF:HIGH

θr-θ	t-0	37	74	37	2.00:1
θr-θ	n-0	28	56	28	2.00:1
θr-θ	k-0	25	50	25	2.00:1
spl-p	t-0	37	74	37	2.00:1
spl-p	n-0	28	56	28	2.00:1
spl-p	k-0	25	50	25	2.00:1
pr-p	t-0	39	78	39	2.00:1
pr-p	n-0	30	60	30	2.00:1
pr-p	k-0	36	72	36	2.00:1

(d) SIWI:LOW SFWF:LOW

$\theta r-\theta$ b-0	0	0	0	---
$\theta r-\theta$ δ -0	1	2	1	2.00:1
$\theta r-\theta$ ζ -0	0	0	0	---
spl-p b-0	0	0	0	---
spl-p δ -0	1	2	1	2.00:1
spl-p ζ -0	0	0	0	---
pr-p b-0	1	2	1	2.00:1
pr-p δ -0	2	4	2	2.00:1
pr-p ζ -0	1	2	1	2.00:1

(6) SIWI: Context Dependent Processes

SFWF: Context Independent Processes

(a) SIWI:HIGH SFWF:HIGH

st-t k-t	34	68	34	2.00:1
st-t s-t	27	54	27	2.00:1
st-t t ζ -t	11	22	11	2.00:1
tr-t k-t	33	66	33	2.00:1
tr-t s-t	25	50	25	2.00:1
tr-t t ζ -t	19	38	19	2.00:1
dr-d k-t	28	56	28	2.00:1
dr-d s-t	20	40	20	2.00:1
dr-d t ζ -t	14	28	14	2.00:1

(b) SIWI:HIGH SFWF:LOW

st-t η -n	15	39	15	2.00:1
st-t δ -d	11	22	11	2.00:1
st-t l-j	11	22	11	2.00:1
tr-t η -n	13	26	13	2.00:1
tr-t δ -d	10	20	10	2.00:1
tr-t l-j	10	20	10	2.00:1
dr-d η -n	8	16	8	2.00:1
dr-d δ -d	5	10	5	2.00:1
dr-d l-j	5	10	5	2.00:1

(c) SIWI:LOW SFWF:HIGH

$\theta r-\theta$ k-t	23	46	23	2.00:1
$\theta r-\theta$ s-t	15	30	15	2.00:1
$\theta r-\theta$ t ζ -t	9	18	9	2.00:1

spl-p k-t	23	46	23	2.00:1
spl-p s-t	15	30	15	2.00:1
spl-p tʃ-t	9	18	9	2.00:1
pr-p k-t	24	48	24	2.00:1
pr-p s-t	17	34	17	2.00:1
pr-p tʃ-t	11	22	11	2.00:1

(d) SIWI:LOW SFWF:LOW

θr-θ ʃ-n	3	6	3	2.00:1
θr-θ ʒ-d	0	0	0	---
θr-θ l-j	0	0	0	---
spl-p ʃ-n	3	6	3	2.00:1
spl-p θ-d	0	0	0	---
spl-p l-j	0	0	0	---
pr-p ʃ-n	4	8	4	2.00:1
pr-p θ-d	1	2	1	2.00:1
pr-p l-j	1	2	1	2.00:1

APPENDIX 9

Table 5.17: Rank Ordering of FLOSS-values for All Combinations of Processes Operating in the SIWI-place in structure: Study 2

Rank	Processes	Relationship	FLOSS-value
1	k-t; st-t	IF/Unaltered PS	57
2	f-p; p-b	CF/Unaltered PS	52
3	k-t; tr-t	IF/Unaltered PS	49
4	st-t; k-t	co-feed IF/Unaltered PS	43
5	k-t; s-t	Type2IF	41
6	∫-t; k-t	Conspiring/Unaltered PS	40
7	t-d; dr-d	IF/Unaltered PS	37
7	s-t; k-t	co-feed Type2IF	37
7	k-t; t-d	CF/Unaltered PS	37
10	l-w; r-w	Conspiring/Unaltered PS	35
10	sp-p; p-b	CF/Unaltered PS	35
12	tr-t; k-t	co-feed IF/Unaltered PS	33
12	l-w; k-t	Type3+4IF	33
12	k-t; l-w	co-feed Type3+4IF	33
12	t∫-t; k-t	Conspiring/Unaltered PS	33
16	st-t; t-d	CF/Unaltered PS	31
17	∅-t; k-t	Conspiring/Unaltered PS	30
17	r-w; k-t	Type3+4IF	30
17	k-t; r-w	co-feed Type3+4IF	30
20	p-b; bl-b	IF/Unaltered PS	29
21	st-t; tr-t	Type1IF	28
21	st-t; s-t	Conspiring/Unaltered PS	28
21	kr-k; k-t	CF/Altered PS	28
24	s-t; ∫-t	Conspiring/Unaltered PS	27
24	kw-k; k-t	CF/Altered PS	27
26	sk-k; k-t	CF/Unaltered PS	26
27	f-p; pl-p	IF/Unaltered PS	25
27	l-j; k-t	Type3IF	25
27	l-j; p-b	Type3+4IF	25
27	p-b; l-j	co-feed Type3+4IF	25

27	str-t; k-t	Conspiring/Unaltered PS	25
27	ʃ-t; t-d	CF/Unaltered PS	25
27	k-g; g-d	CF/Unaltered PS	25
34	p-b;br-b	IF/Unaltered PS	24
34	ʃ-t;tr-t	IF/Unaltered PS	24
34	k-g;gr-g	IF/Unaltered PS	24
34	br-b;p-b	co-feed IF/Unaltered PS	24
34	r-w;k-g	Type3+4IF	24
34	k-g;r-w	co-feed Type3+4IF	24
34	st-t;ʃ-t	Conspiring/Unaltered PS	24
34	pl-p;p-b	CF/Altered PS	24
34	kl-k;k-t	CF/Unaltered PS	24
34	tr-t;s-t	Type2IF	24
34	l-w;k-g	Type3+4IF	24
34	k-g;l-w	co-feed Type3+4IF	24
46	f-p;sp-p	IF/Unaltered PS	23
46	sp-p;f-p	co-feed IF/Unaltered PS	23
46	skr-k;k-t	CF/Altered PS	23
49	tr-t;ʃ-t	co-feed IF/Unaltered PS	22
49	v-b;p-b	Conspiring/Unaltered PS	22
49	s-t;t-d	CF/Altered PS	22
49	skw-k;k-t	CF/Unaltered PS	22
53	s-t;tr-t	co-feed Type2IF	21
53	r-j;k-t	Type3IF	21
53	k-t;r-j	co-feed Type3IF	21
53	tr-t;tʃ-t	Conspiring/Unaltered PS	21
53	st-t;tʃ-t	Conspiring/Unaltered PS	21
53	tr-t;t-d	CF/Altered PS	21
53	f-v;v-b	CF/Unaltered PS	21
53	tʃ-t;t-d	CF/Unaltered PS	21
53	r-w;s-t	Type4(i)IF	21
62	θ-t;tr-t	IF/Unaltered PS	20
62	tr-t;st-t	co-feed Type1IF	20
62	r-j;p-b	Type3+4IF	20
62	p-b;r-j	co-feed Type3+4IF	20
62	θ-t;s-t	Conspiring/Unaltered PS	20
62	spl-p;p-b	CF/Unaltered PS	20

62	spr-p;p-b	CF/Unaltered PS	20
69	l-j;r-j	Conspring/Unaltered PS	19
69	st-t;θ-t	Conspiring/Unaltered PS	19
69	kr-k;k-g	CF/Altered PS	19
69	fl-f;f-p	CF/Altered PS	19
73	r-w;θ-t	Type3IF	18
73	θ-t;r-w	co-feed Type3IF	18
73	s-t;tς-t	Conspiring/Unaltered PS	18
73	ς-t;tς-t	Conspiring/Unaltered PS	18
73	fr-f;f-p	CF/Altered PS	18
78	pl-p;f-p	co-feed IF/Unaltered PS	17
78	dr-d;t-d	co-feed IF/Unaltered PS	17
78	l-j;f-p	Type3IF	17
78	sp-p;l-w	Type4IF(i)	17
78	l-j;k-g	Type3+4IF	17
78	k-g;l-j	co-feed Type3+4IF	17
78	θ-t;ς-t	Conspiring/Unaltered PS	17
78	θ-t;t-d	CF/Unaltered PS	17
86	g-d;dr-d	If/Unaltered PS	16
86	l-w;g-d	Type3IF	16
86	g-d;l-w	co-feed Type3IF	16
86	sp-p;r-w	Type4IF(i)	16
86	sk-k;r-w	Type4IF(i)	16
86	str-t;s-t	Conspiring/Unaltered PS	16
86	sl-s;s-t	CF/Unaltered PS	16
86	str-t;t-d	CF/Unaltered PS	16
94	r-w;g-d	Type3IF	15
94	g-d;r-w	co-feed Type3IF	15
94	str-t;st-t	Conspiring/Altered PS	15
94	λ-d;t-d	Conspiring/Unaltered PS	15
94	kw-k;k-t	CF/Altered PS	15
99	k-g;gl-g	IF/Unaltered PS	14
99	tr-t;θ-t	co-feed IF/Unaltered PS	14
99	l-j;s-t	Type3+4IF	14
99	s-t;l-j	co-feed Type3+4IF	14
99	θ-t;tς-t	Conspiring/Unaltered PS	14
99	str-t;ς-t	Conspiring/Unaltered PS	14

99	z-d;t-d	Conspiring/Unaltered PS	14
99	d ₃ -d;t-d	Conspiring/Unaltered PS	14
107	sk-k;kr-k	Type1IF	13
107	r-j;f-p	Type3IF	13
107	spl-p;f-p	Conspiring/Unaltered PS	13
107	spr-p;f-p	Conspiring/Unaltered PS	13
107	kl-k;k-g	CF/Altered PS	13
107	skr-k;k-g	CF/Unaltered PS	13
107	skw-k;k-g	CF/Unaltered PS	13
114	gr-g;k-g	co-feed IF/Unaltered PS	12
114	str-t;tr-t	Conspiring/Altered PS	12
114	gr-g;gl-g	Conspiring Unaltered PS	12
114	sw-s;s-t	CF/Altered PS	12
118	st-t;r-j	Type3IF	11
118	r-j;st-t	co-feed Type3IF	11
118	r-j;k-g	Type3+4IF	11
118	k-g;r-j	co-feed Type3+4IF	11
118	str-t;t ₅ -t	Conspiring/Unaltered PS	11
123	dr-d;g-d	co-feed IF/Unaltered PS	10
123	gl-g;k-g	co-feed IF/Unaltered PS	10
123	kr-k;sk-k	co-feed type1IF	10
123	r-j;t-d	Type3+4IF	10
123	t-d;r-j	co-feed Type3+4IF	10
123	kr-k;kl-k	Conspiring/Unaltered PS	10
123	kr-k;kw-k	Conspiring/Unaltered PS	10
123	str-t;θ-t	Conspiring/Unaltered PS	10
123	z-d;t-d	Conspiring/Unaltered PS	10
132	sk-k;kw-k	Type1IF	9
132	sp-p;l-j	Type3IF	9
132	l-j;sp-p	co-feed Type3IF	9
132	r-j;s-t	Type4IF(i)	9
132	kl-k;kw-k	Conspiring/Unaltered PS	9
137	sp-p;pl-p	Type1IF	8
137	pl-p;sp-p	co-feed Type1IF	8
137	l-j;g-d	Type3IF	8
137	g-d;l-j	co-feed Type3IF	8
137	skr-k;kr-k	Conspiring/Altered PS	8

137	bl-b;br-b	Conspiring/Unaltered PS	8
137	fr-f;fl-f	Conspiring/Unaltered PS	8
137	dr-d;ɖ-d	Conspiring/Unaltered PS	8
137	dr-d;z-d	Conspiring/Unaltered PS	8
137	ɖ-d;g-d	Conspiring/Unaltered PS	8
147	sk-k;kl-k	Type1IF	7
147	kl-k;sk-k	co-feed Type1IF	7
147	skw-k;sk-k	Conspiring/Altered PS	7
147	sl-s;sw-s	Conspiring/Unaltered PS	7
147	dr-d;dʒ-d	Conspiring/Unaltered PS	7
147	dʒ-d;g-d	Conspiring/Unaltered PS	7
147	gr-g;g-d	CF/Altered PS	7
147	tʃ-d -dʒ-d	CF/Unaltered PS	7
155	kw-k;sk-k	co-feed Type1IF	6
155	kr-k;skw-k	Conspiring/Unaltered PS	6
155	kl-k;skr-k	Conspiring/Unaltered PS	6
155	θr-θ;θ-t	CF/Altered PS	6
159	sp-p;pr-p	Type1IF	5
159	pr-p;sp-p	co-feed Type1IF	5
159	skr-k;sk-k	Conspiring/Altered PS	5
159	ʃ-d;z-d	Conspiring/Unaltered PS	5
159	ʃ-d;dʒ-d	Conspiring/Unaltered PS	5
159	bl-b;v-b	Conspiring/Unaltered PS	5
159	br-b;v-b	Conspiring/Unaltered PS	5
159	dr-dʒ-d	Conspiring/Unaltered PS	5
159	z-d;g-d	Conspiring/Unaltered PS	5
159	skw-k;sk-k	Conspiring/Altered PS	5
159	gl-g;g-d	CF/Unaltered PS	5
159	sl-s;s-z	CF/Unaltered PS	5
159	s-z;z-d	CF/Unaltered PS	5
172	sp-p;r-j	Type3IF	4
172	r-j;sp-p	co-feed Type3IF	4
172	sk-k;r-j	Type3IF	4
172	r-j;sk-k	co-feed Type3IF	4
172	spl-p;sp-p	Conspiring/Altered PS	4
172	spr-p;sp-p	Conspiring/Altered PS	4
172	kl-k;skw-k	Conspiring/Unaltered PS	4

172	z-d;dʒ-d	Conspiring/Unaltered PS	4
172	fr-f;f-v	CF/Unaltered PS	4
172	fl-f;f-v	CF/Unaltered PS	4
172	θ-ʃ;ʃ-d	CF/Unaltered PS	4
183	r-j;g-d	Type3IF	3
183	g-d;r-j	co-feed Type3IF	3
183	r-j;θ-t	Type3IF	3
183	θ-t;r-j	co-feed Type3IF	3
183	spl-p;pl-p	Conspiring/Altered PS	3
183	skr-k;skw-k	Conspiring/Unaltered PS	3
183	ʒ-d;ʒ-d	Conspiring/Unaltered PS	3
183	ʒ-d;g-d	Conspiring/Unaltered PS	3
183	sw-s;s-z	CF/Unaltered PS	3
192	z-d;ʒ-d	Conspiring/Unaltered PS	2
192	ʒ-d;dʒ-d	Conspiring/Unaltered PS	2
194	spr-p;pr-p	Conspiring/Altered PS	1
194	spl-p;spr-p	Conspiring/Unaltered PS	0

APPENDIX 10

Table 5.18: Rank Ordering of FLOSS-values for All Combinations of Processes Operating in the SFWF place in structure: Study 2

Rank	Processes	Relationship	FLOSS-value
1	n-0;t-0	Conspiring/Altred PS	94
2	t-0;k-0	Conspiring/Altered PS	87
2	k-t;t-0	CF/Altered PS	87
4	n-0;d-0	Conspiring/Altered PS	86
4	t-0;s-0	Conspiring/Altered PS	86
4	s-t;t-0	CF/Altered PS	86
7	d-t;t-0	CF/Unaltered PS	81
7	t-0;d-0	Conspiring/Altered PS	81
9	n-0;k-0	Conspiring/Unaltered PS	74
10	n-0;s-0	Conspiring/Altered PS	66
11	d-0;k-0	Conspiring/Unaltered PS	65
12	p-0;t-0	Conspiring/Altered PS	64
13	k-t;s-0	Type3IF	62
14	m-0;t-0	Conspiring/Unaltered PS	61
15	k-t;d-t	Conspiring/Unaltered PS	59
16	k-0;s-0	Conspiring/Altered PS	58
17	t-0;z-0	Conspiring/Unaltered PS	53
17	d-0;s-0	Conspiring/Altered PS	53
19	t-0;t _f -0	Conspiring/Unaltered PS	52
19	t _f -t;t-0	CF/Unaltered PS	52
21	t-0;f-0	Conspiring/Altered PS	51
21	t-0;v-0	Conspiring/Unaltered PS	51
21	k-0;e-0	Conspiring/Unaltered PS	51
24	n-0;p-0	Conspiring/Unaltered PS	49
24	t-0;g-0	Conspiring/Unaltered PS	49
26	s-t;k-t	Type2IF	48
26	k-t;s-t	co-feed Type2IF	48
28	p-0;k-0	Conspiring/Unaltered PS	47
29	m-0;k-0	Conspiring/Unaltered PS	45
29	t-0;d ₃ -0	Conspiring/Unaltered PS	45
29	s-t;k-0	Type3IF	45

29	k-0;s-t	co-feed Type3IF	45
33	n-0;v-0	Conspiring/Unaltered PS	43
33	n-0;z-0	Conspiring/Unaltered PS	43
35	p-0;d-0	Conspiring/Unaltered PS	42
35	t-0;ξ-0	Conspiring/Unaltered PS	42
35	ξ-t;t-0	CF/Unaltered PS	42
38	n-0;m-0	Conspiring/Unaltered PS	41
38	n-0;tξ-0	Conspiring/Altered PS	41
38	t-0;θ-0	Conspiring/Altered PS	41
38	θ-t;t-0	CF/Altered PS	41
38	g-k;k-t	CF/Unaltered PS	41
38	b-0;t-0	Conspiring/Unaltered PS	41
38	m-0;d-0	Conspiring/Unaltered PS	41
45	n-0;f-0	Conspiring/Unaltered PS	40
45	p-0;s-0	Conspiring/Altered PS	40
45	k-0;z-0	Conspiring/Unaltered PS	40
45	f-p;t-0	Type3IF	40
45	η-n;t-0	Type3IF	40
45	t-0;f-p	co-feed Type3IF	40
45	t-0;η-n	co-feed Type3IF	40
52	k-0;v-0	Conspiring/Unaltered PS	39
52	s-0;z-0	Conspiring/Unaltered PS	39
52	z-s;s-0	CF/Unaltered PS	39
52	tξ-t;k-t	Conspiring/Unaltered PS	39
56	t-0;ξ-0	Conspiring/Unaltered PS	38
56	d-0;f-0	Conspiring/Unaltered PS	38
56	d-0;z-0	Conspiring/Unaltered PS	38
56	z-d;d-0	CF/Unaltered PS	38
56	k-0;tξ-0	Conspiring/Unaltered PS	38
61	t-0;ξ-0	Conspiring/Unaltered PS	37
62	n-0;g-0	Conspiring/Unaltered PS	36
62	d-0;v-0	Conspiring/Unaltered PS	36
62	η-n;n-0	CF/Unaltered PS	36
65	n-0;dξ-0	Conspiring/Altered PS	35
65	m-0;s-0	Conspiring/Unaltered PS	35
65	d-0;tξ-0	Conspiring/Unaltered PS	35
65	g-d;d-t	CF/Unaltered PS	35
69	n-0;θ-0	Conspiring/Altered PS	34

69	tʃ-t;d-t	Conspiring/Unaltered PS	34
71	k-0;f-0	Conspiring/Unaltered PS	33
71	f-0;s-0	Conspiring/Unaltered PS	33
71	v-0;s-0	Conspiring/Unaltered PS	33
74	n-0;b-0	Conspiring/Unaltered PS	32
74	n-0;ʃ-0	Conspiring/Unaltered PS	32
74	k-0;dʒ-0	Conspiring/Unaltered PS	32
77	k-0;g-0	Conspiring/Unaltered PS	31
77	g-k;k-0	Conspiring/Unaltered PS	31
77	ʃ-t;k-t	Conspiring/Unaltered PS	31
80	m-0;p-0	Conspiring/Altered PS	30
80	d-0;dʒ-0	Conspiring/Unaltered PS	30
80	dʒ-d;d-0	CF/Unaltered PS	30
80	z-d;d-t	CF/Unaltered PS	30
84	n-0;ʒ-0	Conspiring/Unaltered PS	29
84	b-0;k-0	Conspiring/Unaltered PS	29
84	s-0;tʃ-0	Conspiring/Unaltered PS	29
84	s-t;p-0	Type3IF	29
84	p-0;s-t	co-feed Type3IF	29
89	n-0;ʒ-0	Conspiring/Unaltered PS	28
89	d-0;θ-0	Conspiring/Unaltered PS	28
89	k-0;ʃ-0	Conspiring/Unaltered PS	28
89	θ-0;s-0	Conspiring/Unaltered PS	28
89	s-0;dʒ-0	Conspiring/Unaltered PS	28
94	d-0;g-0	Conspiring/Unaltered PS	27
94	g-d;d-0	CF/Unaltered PS	27
94	k-0;ʒ-0	Conspiring/Unaltered PS	27
94	θ-t;k-t	Conspiring/Unaltered PS	27
94	z-s;s-t	CF/Unaltered PS	27
94	θ-t;k-t	Type1IF	27
94	k-t;θ-t	co-feed Type1IF	27
94	ʒ-n;s-0	Type3IF	27
94	s-0;ʒ-n	co-feed Type3IF	27
103	p-0;z-0	Conspiring/Unaltered PS	26
103	ʃ-t;d-t	Conspiring/Unaltered PS	26
103	dʒ-d;d-t	CF/Unaltered PS	26
103	θ-t;k-0	Type3IF	26
103	k-0;θ-t	co-feed type3IF	26

109	b-0;d-0	Conspiring/Unaltered PS	25
109	d-0;đ-0	Conspiring/Unaltered PS	25
109	đ-d;d-0	CF/Unaltered PS	25
109	d-0;ś-0	Conspiring/Unaltered PS	25
109	k-0;ź-0	Conspiring/Unaltered PS	25
109	s-0;ś-0	Conspiring/Unaltered PS	25
114	s-t;tś-t	Conspiring/Unaltered PS	24
114	d-0;ź-0	Conspiring/Unaltered PS	24
114	ź-d;d-0	CF/Unaltered PS	24
114	đ-0;s-0	Conspiring/Unaltered PS	24
114	p-0;v-0	Conspiring/Unaltered PS	24
119	m-0;z-0	Conspiring/Unaltered PS	23
119	m-0;tś-0	Conspiring/Unaltered PS	23
119	p-0;tś-0	Conspiring/Unaltered PS	23
119	b-0;s-0	Conspiring/Unaltered PS	23
119	g-0;s-0	Conspiring/Unaltered PS	23
119	s-0;ź-0	Conspiring/Unaltered PS	23
119	k-t;t-ł	CF/Unaltered PS	23
126	s-t;ś-t	Conspiring/Unaltered PS	22
126	θ-t;d-t	Conspiring/Unaltered PS	22
128	m-0;v-0	Conspiring/unaltered PS	21
128	p-0;f-0	Conspiring/Unaltered PS	21
128	f-p;p-0	CF/Unaltered PS	21
131	t-ł;d-ł	Conspiring/Unaltered PS	20
131	d-t;d-ł	CF/Unaltered PS	20
131	đ-d;d-t	CF/Unaltered PS	20
131	ź-d;d-t	CF/Unaltered PS	20
135	m-0;f-0	Conspiring/Altered PS	19
136	f-0;z-0	Conspiring/Unaltered PS	18
136	v-0;z-0	Conspiring/Unaltered PS	18
136	θ-t;s-t	Type2IF	18
136	s-t;θ-t	co-feed Type2IF	18
136	ŋ-n;s-t	Type4IF(i)	18
141	ś-t;tś-t	Conspiring/Unaltered PS	17
141	p-0;dź-0	Conspiring/Unaltered PS	17
141	f-0;v-0	Conspiring/Unaltered PS	17
141	v-f;f-0	CF/Unaltered PS	17
145	p-0;g-0	Conspiring/Unaltered PS	16

145	p-0;θ-0	Conspiring/Altered PS	16
145	z-0;tς-0	Conspiring/Unaltered PS	16
148	m-0;d3-0	Conspiring/Unaltered PS	15
148	p-0;ς-0	Conspiring/Unaltered PS	15
148	v-0;tς-0	Conspiring/Unaltered PS	15
148	p-2;t-2	Conspiring/Unaltered PS	15
148	t-2;s-2	Conspiring/Unaltered PS	15
148	s-t;t-2	CF/Unaltered PS	15
154	f-0;tς-0	Conspiring/Unaltered PS	14
154	z-0;d3-0	Conspiring/Unaltered PS	14
156	m-0;g-0	Conspiring/Unaltered PS	13
156	m-0;θ-0	Conspiring/Unaltered PS	13
156	p-0;b-0	Conspiring/Unaltered PS	13
156	b-p;p-0	CF/Unaltered PS	13
156	p-0;θ-0	Conspiring/Unaltered PS	13
156	θ-ϕ; z-ϕ	Conspiring/unaltered PS	13
156	d3-tς;tς-t	CF/Unaltered PS	13
156	v-0;d3-0	Conspiring/Unaltered PS	13
156	f-p;m-0	Type3IF	13
156	m-0;f-p	co-feed type3IF	13
156	θ-t;p-0	Type3IF	13
156	p-0;θ-t	co-feed type3IF	13
168	f-0;d3-0	Conspiring/Unaltered PS	12
168	p-0;3-0	Conspiring/Unaltered PS	12
170	θ-t;tς-t	Conspiring/Unaltered PS	11
170	m-0;χ-0	Conspiring/Unaltered PS	11
170	m-0;ς-0	Conspiring/Unaltered PS	11
170	g-0;z-0	Conspiring/Unaltered PS	11
170	v-0;θ-0	Conspiring/Unaltered PS	11
170	χ-0;z-0	Conspiring/Unaltered PS	11
170	z-0;ς-0	Conspiring/Unaltered PS	11
177	m-0;b-0	Conspiring/Unaltered PS	10
177	m-0;3-0	Conspiring/Unaltered PS	10
177	b-0;z-0	Conspiring/Unaltered PS	10
177	z-0;3-0	Conspiring/Unaltered PS	10
177	f-0;θ-0	Conspiring/Altered PS	10
177	θ-0;tς-0	Conspiring/Unaltered PS	10
177	tς-0;d3-0	Conspiring/Unaltered PS	10

177	d ₃ -t ;t ₅ -0	CF/Unaltered PS	10
185	g-0;f-0	Conspiring/Unaltered PS	9
185	g-0;t ₅ -0	Conspiring/Unaltered PS	9
185	v-0;ø-0	Conspiring/Unaltered PS	9
185	5-0;t ₅ -0	Conspiring/Unaltered PS	9
185	t-2;t ₅ -2	Conspiring/Unaltered PS	9
185	t ₅ -t;t-2	CF/Unaltered PS	9
191	b-0;f-0	Conspiring/Unaltered PS	8
191	b-0;v-0	Conspiring/Unaltered PS	8
191	v-b;b-0	CF/Unaltered PS	8
191	g-0;v-0	Conspiring/Unaltered PS	8
191	f-0;ø-0	Conspiring/Unaltered PS	8
191	v-0;s-0	Conspiring/Unaltered PS	8
191	v-0;3-0	Conspiring/Unaltered PS	8
191	v-f;f-p	CF/Unaltered PS	8
199	z-d;g-d	Conspiring/Unaltered PS	7
199	ø-t;5-t	Conspiring/Unaltered PS	7
199	b-0;t ₅ -0	Conspiring/Unaltered PS	7
199	f-0;3-0	Conspiring/Unaltered PS	7
199	ø-0;t ₅ -0	Conspiring/Unaltered PS	7
199	ø-0;d ₃ -0	Conspiring/Unaltered PS	7
199	d ₃ -d;g-d	Conspiring/Unaltered PS	7
206	z-d;d ₃ -d	Conspiring/Unaltered PS	6
206	g-0;d ₃ -0	Conspiring/Unaltered PS	6
206	3-0;t ₅ -0	Conspiring/Unaltered PS	6
206	p-2;d-2	Conspiring/Unaltered PS	6
206	t-2;z-2	Conspiring/Unaltered PS	6
206	d-2;s-2	Conspiring/Unaltered PS	6
206	s-2;z-2	Conspiring/Unaltered PS	6
206	z-s;s-2	CF/Unaltered PS	6
214	ø-0;d ₃ -0	Conspiring/Unaltered PS	5
214	p-2;t ₅ -2	Conspiring/Unaltered PS	5
214	d-2;t ₅ -2	Conspiring/Unaltered PS	5
214	v-b;b-p	CF/Unaltered PS	5
214	5-t;t-2	CF/Unaltered PS	5
219	b-0;d ₃ -0	Conspiring/Unaltered PS	4
219	ø-0;5-0	Conspiring/Unaltered PS	4
219	5-0;d ₃ -0	Conspiring/Unaltered PS	4

219	ʒ-0;dʒ-0	Conspiring/Unaltered PS	4
219	p-ʔ;s-ʔ	Conspiring/Unaltered PS	4
219	p-ʔ;z-ʔ	Conspiring/Unaltered PS	4
219	b-ʔ;t-ʔ	Conspiring/Unaltered PS	4
219	t-ʔ;dʒ-ʔ	Conspiring/Unaltered PS	4
219	d-ʔ;z-ʔ	Conspiring/Unaltered PS	4
219	f-p;b-p	Conspiring/Unaltered PS	4
219	θ-0;ʝ-0	Conspiring/Unaltered PS	4
219	ʝ-θ;θ-0	CF/Unaltered PS	4
231	ʝ-d;z-d	Conspiring/Unaltered PS	3
231	z-d;ʒ-d	Conspiring/Unaltered PS	3
231	b-0;θ-0	Conspiring/Unaltered PS	3
231	g-0;θ-0	Conspiring/Unaltered PS	3
231	g-0;ʃ-0	Conspiring/Unaltered PS	3
231	θ-0;ʒ-0	Conspiring/Unaltered PS	3
231	ʒ-d;g-d	Conspiring/Unaltered PS	3
233	ʝ-d;g-d	Conspiring/Unaltered PS	3
233	g-d;d-ʔ	CF/Unaltered PS	3
233	θ-t;f-p	Type3IF	3
233	f-p;θ-t	co-feed Type3IF	3
233	b-0;g-0	Conspiring/Unaltered PS	3
245	ʝ-d;dʒ-d	Conspiring/Unaltered PS	2
245	ʒ-d;dʒ-d	Conspiring/Unaltered PS	2
245	b-0;ʃ-0	Conspiring/Unaltered PS	2
245	d-ʔ;dʒ-ʔ	Conspiring/Unaltered PS	2
245	dʒ-d;d-ʔ	CF/Unaltered PS	2
250	g-0;ʝ-0	Conspiring/Unaltered PS	1
250	ʝ-0;ʃ-0	Conspiring/Unaltered PS	1
250	ʝ-0;ʒ-0	Conspiring/Unaltered PS	1
250	p-ʔ;b-ʔ	Conspiring/Unaltered PS	1
250	b-p;p-ʔ	CF/Unaltered PS	1
250	p-ʔ;dʒ-ʔ	Conspiring/Unaltered PS	1
250	b-ʔ;d-ʔ	Conspiring/Unaltered PS	1
250	b-ʔ;tʃ-ʔ	Conspiring/Unaltered PS	1
250	s-ʔ;dʒ-ʔ	Conspiring/Unaltered PS	1
250	ʝ-θ;θ-t	CF/Unaltered PS	1
250	θ-t;t-ʔ	CF/Unaltered PS	1

250	b-0;3-0	Conspiring/Unaltered PS	1
262	7-d;3-d	Conspiring/Unaltered PS	0
262	b-0;7-0	Conspiring/Unaltered PS	0
262	g-0;3-0	Conspiring/Unaltered PS	0
262	5-0;3-0	Conspiring/Unaltered PS	0
262	b-1;s-1	Conspiring/Unaltered PS	0
262	b-1;z-1	Conspiring/Unaltered PS	0
262	b-1;d -1	Conspiring/Unaltered PS	0
262	s-1;t -1	Conspiring/Unaltered PS	0
262	z-1;t -1	Conspiring/Unaltered PS	0
262	z-1;d3-1	Conspiring/Unaltered PS	0
262	d3-t5;t5-1	CF/Unaltered PS	0
262	7-d;d-1	CF/Unaltered PS	0
262	3-d;d-1	CF/Unaltered PS	0

APPENDIX 11

Table 5.19: Rank Ordering of IMH for All Combinations of Processes Operating in the SIWI-place in structure (exclusive of IMH of 2:1)

Rank	Processes	Relationship	I M H
1	k-t;st-t	IF/Unaltered PS	2.38:1
2	st-t;t-t	Conspiring/Unaltered PS	2.31:1
3	g-d;dr-d	IF/Unaltered PS	2.30:1
3	t-d;dr-d	IF/Unaltered PS	2.30:1
3	st-t;k-t	co-feed IF/Unaltered PS	2.30:1
6	dr-d;t-d	co-feed IF/Unaltered PS	2.27:1
7	-t;tr-t	IF/Unaltered PS	2.25:1
7	str-t;tr-t	Conspiring/Altered PS	2.25:1
7	-t;t-t	Conspiring/Unaltered PS	2.25:1
10	t-t;tr-t	IF/Unaltered PS	2.21:1
11	k-t;tr-t	IF/Unaltered PS	2.20:1
11	st-t;tr-t	Type1IF	2.20:1
11	skw-k;sk-k	Conspiring/Altered PS	2.20:1
11	t-t;t-t	Conspiring/Unaltered PS	2.20:1
11	z-d;t-d	Conspiring/Unaltered PS	2.20:1
11	tr-t;t-d	CF/Altered PS	2.20:1
11	gr-g;g-d	CF/Altered PS	2.20:1
18	tr-t;t-t	co-feed IF/Unaltered PS	2.19:1
19	f-p;pl-p	IF/Unaltered PS	2.17:1
19	k-g;gr-g	IF/Unaltered PS	2.17:1
19	dr-d;z-d	Conspiring/Unaltered PS	2.17:1
19	st-t;t-d	CF/Unaltered PS	2.17:1
23	t-t;k-t	Conspiring/UnalteredPS	2.16:1
23	-t;t-d	CF/Unaltered PS	2.16:1
25	l-w;r-w	Conspiring/Unaltered PS	2.15:1
25	f-p;p-b	CF/Unaltered PS	2.15:1
27	sk-k;kw-k	Type1IF	2.14:1
27	k-t;s-t	Type2IF	2.14:1
27	s-t;k-t	co-feed Type2IF	2.14:1
27	s-t;t-t	Conspiring/Unaltered PS	2.14:1
27	kw-k;k-t	CF/Altered PS	2.14:1

27	k-t;t-d	CF/Unaltered PS	2.14:1
33	dr-d;g-d	co-feed IF/Unaltered PS	2.13:1
33	tr-t;st-t	co-feed Type1IF	2.13:1
33	ʃ-t;k-t	Conspiring/Unaltered PS	2.13:1
33	fl-f;f-p	CF/Altered PS	2.13:1
37	tr-t;tʃ-t	Conspiring/Unaltered PS	2.12:1
37	tʃ-t;t-d	CF/Unaltered PS	2.12:1
39	tr-t;k-t	co-feed IF/Unaltered PS	2.11:1
39	tr-t;s-t	Type2IF	2.11:1
39	s-t;tr-t	co-feed Type2IF	2.11:1
39	str-t;tʃ-t	Conspiring/Unaltered PS	2.11:1
43	st-t;ʃ-t	Conspiring/Unaltered PS	2.10:1
43	sp-p;p-b	CF/Unaltered PS	2.10:1
45	p-b;bl-b	IF/Unaltered PS	2.08:1
45	tr-t;θ-t	co-feed IF/Unaltered PS	2.08:1
45	st-t;s-t	Conspiring/Unaltered PS	2.08:1
45	ʒ-d;t-d	Conspiring/Unaltered PS	2.08:1
49	pl-p;f-p	co-feed IF/Unaltered PS	2.08:1
49	θ-t;ʃ-t	Conspiring/Unaltered PS	2.07:1
49	sl-s;s-t	CF/Unaltered PS	2.07:1
49	str-t;t-d	CF/Unaltered PS	2.07:1
53	s-t;tʃ-t	Conspiring/Unaltered PS	2.06:1
53	st-t;θ-t	Conspiring/Unaltered PS	2.06:1
53	pl-p;p-b	CF/Altered PS	2.06:1
53	kr-k;k-g	CF/Altered PS	2.06:1
57	skw-k;k-t	CF/Unaltered PS	2.05:1
57	f-p;sp-p	IF/Unaltered PS	2.05:1
57	sp-p;f-p	co-feed IF/Unaltered PS	2.05:1
57	kl-k;k-t	CF/Unaltered PS	2.05:1
61	bl-b;p-b	co-feed IF/Unaltered PS	2.04:1
61	str-t;k-t	Conspiring/Unaltered PS	2.04:1
61	θ-t;k-t	Conspiring/Unaltered PS	2.04:1
61	kr-k;k-t	CF/Altered PS	2.04:1
61	sk-k;k-t	CF/Unaltered PS	2.04:1
61	r-w;k-t	Type3+4IF	2.03:1

APPENDIX 12

Table 5.20: Rank Ordering of IMH for All Combinations of Processes Operating in the SFWF-place in structure (exclusive of IMH of 2:1)

Rank	Processes	Relationship	I M H
1	n-0;d-0	Conspiring/Unaltered PS	2.43:1
2	n-0;k-0	Conspiring/Unaltered PS	2.21:1
3	d ₃ -d;g-d	Conspiring/Unaltered PS	2.20:1
4	k-t;s-0	Type3IF	2.15:1
4	s-0;k-t	co-feed Type3IF	2.25:1
6	n-0;t-0	Conspiring/unaltered PS	2.12:1
6	g-k;k-t	CF/Unaltered PS	2.12:1
6	θ-t;k-t	Type1IF	2.12:1
6	k-t;θ-t	co-feed Type1IF	2.12:1
10	s-t;ξ-t	Conspiring/Unaltered PS	2.11:1
10	t-0;k-0	Conspiring/Unaltered PS	2.11:1
10	k-t;t-0	CF/Altered PS	2.11:1
13	p-0;z-0	Conspiring/Unaltered PS	2.10:1
13	t-0;s-0	Conspiring/Unaltered PS	2.10:1
13	s-t;t-0	CF/Altered PS	2.10:1
13	k-t;d-t	Conspiring/Unaltered PS	2.10:1
13	t-0;d-0	Conspiring/Unaltered PS	2.10:1
13	d-t;t-0	CF/Unaltered PS	2.10:1
19	d-0;f-0	Conspiring/Unaltered PS	2.09:1
19	tξ-t;k-t	Conspiring/Unaltered PS	2.09:1
21	m-0;p-0	Conspiring/Unaltered PS	2.08:1
21	m-0;k-0	Conspiring/Unaltered PS	2.08:1
21	z-d;d-t	CF/Unaltered PS	2.08:1
24	ξ-t;tξ-t	Conspiring/Unaltered PS	2.07:1
24	n-0;θ-0	Conspiring/Unaltered PS	2.07:1
24	n-0;s-0	Conspiring/Unaltered PS	2.07:1
24	t-0;v-0	Conspiring/Unaltered PS	2.07:1
24	d-0;k-0	Conspiring/Unaltered PS	2.07:1
24	g-d;d-t	CF/Unaltered PS	2.07:1
30	s-t;k-t	Type2IF	2.07:1
30	k-t;s-t	co-feed Type2IF	2.07:1

30	tʃ-t;d-t	Conspiring/unaltered PS	2.07:1
33	k-0;v-0	Conspiring/Unaltered PS	2.06:1
33	k-0;s-0	Conspiring/Unaltered PS	2.06:1
33	k-0;tʃ-0	Conspiring/Unaltered PS	2.06:1
33	θ-t;s-t	Type2IF	2.06:1
33	s-t;θ-t	co-feed Type2IF	2.06:1
38	m-0;v-0	Conspiring/Unaltered PS	2.05:1
38	m-0;tʃ-0	Conspiring/Unaltered PS	2.05:1
38	p-0;t-0	Conspiring/Unaltered PS	2.05:1
38	p-0;d-0	Conspiring/Unaltered PS	2.05:1
38	p-0;f-0	Conspiring/Unaltered PS	2.05:1
38	f-p;p-0	CF/Unaltered PS	2.05:1
38	s-t;k-0	Type3IF	2.05:1
38	k-0;s-t	co-feed type3IF	2.05:1
46	m-0;t-0	Conspiring/Unaltered PS	2.04:1
46	t-0;f-0	Conspiring/Unaltered PS	2.04:1
46	t-0;z-0	Conspiring/Unaltered PS	2.04:1
46	θ-t;k-t	Conspiring/Unaltered PS	2.04:1
46	ʃ-t;d-t	Conspiring/Unaltered PS	2.04:1
46	dʒ-d;d-t	CF/Unaltered PS	2.04:1
46	z-s;s-t	CF/Unaltered PS	2.04:1
53	n-0;tʃ-0	Conspiring/Unaltered PS	2.03:1
53	n-0;dʒ-0	Conspiring/Unaltered PS	2.03:1
53	p-0;s-0	Conspiring/Unaltered PS	2.03:1
53	d-0;v-0	Conspiring/Unaltered PS	2.03:1
53	d-0;tʃ-0	Conspiring/Unaltered PS	2.03:1
53	k-0;θ-0	Conspiring/Unaltered PS	2.03:1
53	v-0;s-0	Conspiring/Unaltered PS	2.03:1
53	d-0;z-0	Conspiring/Unaltered PS	2.03:1
53	z-d;d-0	CF/Altered PS	2.03:1
53	m-0;d-0	Conspiring/Unaltered PS	2.03:1
63	n-0;p-0	Conspiring/Unaltered PS	2.02:1
63	n-0;v-0	Conspiring/Unaltered PS	2.02:1
63	n-0;z-0	Conspiring/Unaltered PS	2.02:1
63	t-0;tʃ-0	Conspiring/Unaltered PS	2.02:1
63	tʃ-t;t-0	CF/Altered PS	2.02:1

APPENDIX 13

Table 5.21: Rank Ordering of FLOSS-values for Processes Operating in the SIWI and SFWF Places Simultaneously

Rank	Processes		FLOSS-value	Type of Independent FLOSS-value
	SIWI	SFWF		
1	k-t	t-0	62	H/H
2	f-p	t-0	58	H/H
3	l-w	t-0	54	H/H
4	st-t	t-0	53	H/H
5	k-t	n-0	51	H/H
6	tr-t	t-0	50	H/H
7	k-t	k-0	47	H/H
8	l-w	n-0	46	H/H
9	l-w	k-0	45	H/H
10	f-p	n-0	43	H/H
10	k-t	k-t	43	H/H
12	f-p	k-0	42	H/H
12	k-t	d-t	42	H/H
12	dr-d	t-0	42	H/H
15	st-t	n-0	41	H/H
16	tr-t	n-0	39	H/H
16	r-j	t-0	39	L/H
16	pr-p	t-0	39	H/H
16	f-p	k-t	39	H/H
16	z-d	t-0	39	L/H
21	st-t	k-0	38	H/H
21	tr-t	k-0	38	H/H
21	v-b	t-0	38	L/H
21	k-t	s-t	38	H/H
21	l-w	k-t	38	H/H
26	Ør-Ø	t-0	37	L/H
26	spl-p	t-0	37	L/H
28	dr-d	n-0	36	H/H
29	pr-p	k-0	36	L/H
29	st-t	k-t	34	H/H

29	f-p	d-t	34	H/H
32	tr-t	k-t	33	H/H
32	l-w	d-t	33	H/H
34	dr-d	k-0	31	H/H
34	st-t	d-t	31	H/H
36	pr-p	n-0	30	L/H
36	tr-t	d-t	30	H/H
36	f-p	s-t	30	H/H
36	z-d	n-0	30	L/H
36	k-t	tʃ-t	30	H/H
41	v-b	n-0	29	L/H
42	dr-d	k-t	28	H/H
42	r-j	n-0	28	L/H
42	k-t	g-k	28	H/H
42	θr-θ	n-0	28	L/H
42	spl-p	n-0	28	L/H
42	l-w	s-t	28	H/H
48	st-t	s-t	27	H/H
48	z-d	k-0	27	L/H
50	v-b	k-0	26	L/H
50	r-j	k-0	26	L/H
50	k-t	z-s	26	H/H
53	tr-t	s-t	25	H/H
53	θr-θ	k-0	25	L/H
53	spl-p	k-0	25	L/H
53	dr-d	d-t	25	L/H
53	k-t	ŋ-n	25	H/L
53	z-d	k-t	25	L/H
59	r-j	k-t	24	L/H
59	v-b	k-t	24	L/H
59	pr-p	k-t	24	L/H
59	f-p	tʃ-t	24	H/H
63	k-t	b-p	23	H/L
63	θr-θ	k-t	23	L/H
63	spl-p	k-t	23	L/H
63	l-w	tʃ-t	23	H/H
67	r-j	d-t	22	L/H
67	z-d	d-t	22	L/H

69	v-b	d-t	21	L/H
69	pr-p	d-t	21	L/H
69	k-t	ʔ-0	21	H/L
72	dr-d	s-t	20	H/H
72	θr-θ	d-t	20	L/H
72	spl-p	d-t	20	L/H
72	f-p	g-k	20	H/H
72	k-t	dʒ-tʃ	20	H/L
72	k-t	ʔ-θ	20	H/L
72	k-t	ʔ-d	20	H/L
72	k-t	l-j	20	H/L
72	k-t	b-0	20	H/L
72	k-t	ʃ-0	20	H/L
82	tr-t	tʃ-t	19	H/H
82	f-p	z-s	19	H/H
84	st-t	g-k	18	H/H
84	tr-t	g-k	18	H/H
86	l-w	g-k	17	H/H
86	l-w	z-s	17	H/H
86	pr-p	s-t	17	L/H
86	st-t	z-s	17	H/H
86	z-d	s-t	17	L/H
91	r-j	s-t	16	L/H
91	v-b	s-t	16	L/H
91	tr-t	z-s	16	H/H
91	f-p	ʒ-n	16	H/L
95	st-t	ʒ-n	15	H/L
95	θr-θ	s-t	15	L/H
95	spl-p	s-t	15	L/H
98	dr-d	tʃ-t	14	H/H
98	f-p	b-p	14	H/L
98	l-w	ʒ-n	14	H/L
98	f-p	ʔ-0	14	H/L
98	f-p	ʃ-0	14	H/L
103	tr-t	ʒ-n	13	H/L
103	f-p	dʒ-tʃ	13	H/L
103	f-p	ʔ-θ	13	H/L
103	f-p	ʔ-d	13	H/L

103	f-p	l-j	13	H/L
103	f-p	b-0	13	H/L
109	l-w	b-p	12	H/L
109	st-t	b-p	12	H/L
109	st-t	ʃ-0	12	H/L
109	l-w	ʃ-0	12	H/L
113	st-t	tʃ-t	11	H/H
113	st-t	ʃ-d	11	H/L
113	st-t	l-j	11	H/L
113	l-w	dʒ-tʃ	11	H/L
113	l-w	ʃ-0	11	H/L
113	pr-p	tʃ-t	11	L/H
113	dr-d	g-k	11	H/H
113	dr-d	z-s	11	H/H
113	st-t	dʒ-tʃ	11	H/L
113	st-t	ʃ-0	11	H/L
113	tr-t	b-p	11	H/L
113	l-w	ʃ-d	11	H/L
113	l-w	l-j	11	H/L
113	st-t	b-0	11	H/L
113	st-t	ʃ-0	11	H/L
113	tr-t	ʃ-0	11	H/L
113	l-w	b-0	11	H/L
113	l-w	ʃ-0	11	H/L
113	z-d	tʃ-t	11	L/H
132	v-b	tʃ-t	10	L/H
132	tr-t	ʃ-d	10	H/L
132	tr-t	l-j	10	H/L
132	tr-t	dʒ-tʃ	10	H/L
132	tr-t	ʃ-0	10	H/L
132	tr-t	b-0	10	H/L
132	tr-t	ʃ-0	10	H/L
139	r-j	tʃ-t	9	L/H
139	0r-0	tʃ-t	9	L/H
139	spl-p	tʃ-t	9	L/H
142	dr-d	ʃ-n	8	H/L
142	z-d	g-k	8	L/H
142	z-d	z-s	8	L/H

145	v-b	g-k	7	L/H
145	v-b	z-s	7	L/H
145	pr-p	g-k	7	L/H
145	pr-p	z-s	7	L/H
149	r-j	g-k	6	L/H
149	r-j	z-s	6	L/H
149	θr-θ	g-k	6	L/H
149	θr-θ	z-s	6	L/H
149	spl-p	g-k	6	L/H
149	spl-p	z-s	6	L/H
149	dr-d	b-p	6	H/L
149	dr-d	θ-0	6	H/L
157	dr-d	θ-d	5	H/L
157	dr-d	l-j	5	H/L
157	dr-d	dʒ-tʃ	5	H/L
157	dr-d	θ-θ	5	H/L
157	dr-d	b-0	5	H/L
157	dr-d	ʃ-0	5	H/L
157	z-d	ʃ-n	5	L/L
164	v-b	ʃ-n	4	L/L
164	pr-p	ʃ-n	4	L/L
164	r-j	ʃ-n	4	L/L
167	θr-θ	ʃ-n	3	L/L
167	spl-p	ʃ-n	3	L/L
167	z-d	b-p	3	L/L
167	z-d	θ-0	3	L/L
171	v-b	b-p	2	L/L
171	pr-p	b-p	2	L/L
171	pr-p	θ-0	2	L/L
171	v-b	θ-0	2	L/L
171	z-d	θ-d	2	L/L
171	z-d	l-j	2	L/L
171	z-d	dʒ-tʃ	2	L/L
171	z-d	θ-θ	2	L/L
179	v-b	θ-d	1	L/L
179	v-b	l-j	1	L/L
179	r-j	b-p	1	L/L
179	v-b	dʒ-tʃ	1	L/L

179	v-b	ð-θ	1	L/L
179	θr-θ	b-p	1	L/L
179	spl-p	b-p	1	L/L
179	pr-p	d ₃ -tʃ	1	L/L
179	pr-p	ð-θ	1	L/L
179	pr-p	ð-d	1	L/L
179	θr-θ	ð-0	1	L/L
179	spl-p	ð-0	1	L/L
179	pr-p	b-0	1	L/L
179	pr-p	ʃ-0	1	L/L
179	r-j	ð-0	1	L/L
179	v-b	b-0	1	L/L
179	v-b	ʃ-0	1	L/L
179	z-d	b-0	1	L/L
179	z-d	ʃ-0	1	L/L
198	r-j	ð-d	0	L/L
198	r-j	l-j	0	L/L
198	r-j	d ₃ -tʃ	0	L/L
198	r-j	ð-θ	0	L/L
198	θr-θ	d ₃ -tʃ	0	L/L
198	θr-θ	ð-θ	0	L/L
198	spl-p	d ₃ -tʃ	0	L/L
198	spl-p	d ₃ -tʃ	0	L/L
198	spl-p	ð-d	0	L/L
198	spl-p	l-j	0	L/L
198	spl-p	b-0	0	L/L
198	spl-p	ð-0	0	L/L
198	θr-θ	ð-d	0	L/L
198	θr-θ	l-j	0	L/L
198	θr-θ	b-0	0	L/L
198	θr-θ	ʃ-0	0	L/L
198	r-j	b-0	0	L/L
198	r-j	ʃ-0	0	L/L

APPENDIX 14

Table 5.22: Rank Ordering of IMH for Processes Operating in the SIWI and SFWF Places Simultaneously (exclusive of IMH of 2:1)

Rank	Processes		I M H	Type of Independent FLOSS-value
	SIWI	SFWF		
<hr/>				
1	l-w	k-t	2.14:1	H/H
2	l-w	t-0	2.09:1	H/H
2	l-w	k-0	2.09:1	H/H
4	l-w	n-0	2.08:1	H/H
5	st-t	t-0	2.07:1	H/H
5	l-w	d-t	2.07:1	H/H
7	st-t	g-k	2.06:1	H/H
7	tr-t	g-k	2.06:1	H/H
7	f-p	k-t	2.06:1	H/H
10	f-p	n-0	2.05:1	H/H
10	f-p	k-0	2.05:1	H/H
10	l-w	tſ-t	2.05:1	H/H
10	f-p	tſ-t	2.05:1	H/H
14	f-p	t-0	2.04:1	H/H
14	l-w	s-t	2.04:1	H/H
14	f-p	s-t	2.04:1	H/H
14	k-t	g-k	2.04:1	H/H
18	st-t	k-0	2.03:1	H/H
18	tr-t	k-0	2.03:1	H/H
18	dr-d	n-0	2.03:1	H/H
18	k-t	t-0	2.03:1	H/H
18	k-t	d-t	2.03:1	H/H
18	f-p	d-t	2.03:1	H/H
24	tr-t	t-0	2.02:1	H/H
24	k-t	n-0	2.02:1	H/H