Assessment of Speech Intelligibility in Five South-Eastern Bantu Languages: Critical Considerations

Marlene Carno Jacobson, Ph.D (Witwatersrand)

Department of Speech Pathology and Audiology, University of the Witwatersrand, Johannesburg

Anthony Traill, Ph.D (Witwatersrand)

Department of Linguistics, University of the Witwatersrand, Johannesburg

ABSTRACT
This paper examines criteria underlying the development of tasks and materials for the measurement of speech intelligibility in five South-Eastern Bantu languages. The chief considerations include utterance length, word familiarity and structure, and phonetic balance. It is established that the foundation research necessary for devising materials in South-Eastern Bantu languages on the same basis as those of English, has not yet been conducted. Salient properties of the relevant African languages include multilingualism, dialectal variation, vocabulary differences between rural and urban speakers of the same language, borrowed words, the simple vowel systems, the fairly elaborate consonant systems, prosodic features, certail syllable structure characteristics, and noun morphology. A rationale for the use of two measures of intelligibility is presented, while the need to adapt many criteria characterising English materials is demonstrated.

OPSOMMING
Hierdie referaat ondersoek die kriteria wat onderliggend is aan die ontwikkeling van take en materiaal vir die meting van spraakverstaan-baarheid in vyf Suid-Oosterlike Bantoe tale. Die hoofoorwegings sluit lengte van uiting, woordbekendheid en -struktuur, en fonetiese balans in. Dit is bevestig dat die basiese navorsing wat benodig is vir die saamstel van materiaal in Suid-Oostelike Bantoe-tale nog nie op dieselfde basis as Engels gedoen is nie. Opvallende kenmerke van die relevante Afrika-tale is veeltaligheid, dialektiese variasies, verskille in woordeskat tussen landelike en stedelike gebruikers van dieselfde taal, leenwoorde, die eenvoudige vokaalsisteme, die betreklik uitgebreide konsonantsisteme, prosodiese kenmerke, sekere eienskappe van lettergreepstruktuur, en naamwoordmorfologie. 'n Rasionaal vir die gebruik van twee verstaan-baarheidsmetings is aangebied en die noodsaak om kenmerkende kriteria vir Engelse materiaal aan te pas, word ook uitgewys.

The present paper explores the range of issues confronted on undertaking research which sought to measure the speech intelligibility levels of a series of surgically-treated oral cancer patients each of whom spoke one of five South-Eastern Bantu languages (viz. Jacobson, 1986). The problem was approached by critically "dissecting" the notion of intelligibility in an effort to extract salient properties and, thereafter, by extrapolating applicable criteria of intelligibility measures to the set of phonetico-linguistic conditions characterising these languages. As such, the major concerns underlying speech intelligibility in the present paper are two-fold. The reconciliation of these two aspects forms the rationale for the choice of designated measures of intelligibility, and is represented in the materials themselves.

Nine members of the South-Eastern Bantu family of African languages are recognised and have developed as educational media and literary languages in South Africa (South Africa, 1985):

1. Nguni languages: Zulu, Xhosa, Swazi, and Ndebele, among a total of twelve Nguni languages.
2. Sotho languages: Southern Sotho, Northern Sotho and Tswana, among a total of eleven Sotho languages.
3. Tsonga.
4. Venda.

The present paper happens to deal with the Nguni and Sotho groups of indigenous languages, each of which is sub-divided to form dialect clusters. It was coincidental that the languages spoken by the randomly selected subjects of the study reflect the five most frequently spoken Bantu languages in South Africa, namely, Zulu, Xhosa, Northern Sotho, Southern Sotho, and Tswana.

In view of the number of dialects, some of which are poorly known, certain dialects have been raised to standard forms by taking into account various factors, such as the prominence of a

leader, or tribe size (Ziervogel, Louw, Ferreira, Baumbach & Lombard, 1967). A second major feature of this group of languages is the profound multilingual situation which characterises speakers of the Bantu languages of South Africa.

No materials appear to have been published previously in the relevant African languages for the specific purpose of measuring intelligibility. Speech discrimination word lists used in audiology (e.g. Baragwanath Hospital, 1977) and phonetic inventories (e.g. Hillbrow Hospital, 1981) did not meet those requirements deemed fundamental to the study concerned, namely, clear evidence of the formulation of a set of criteria for item selection, taking into account previous research on intelligibility.

Speech intelligibility is the property of speech communication involving meaning, and is the quality or state of being comprehended or understood. A signal is intelligible to a listener, and for a speech signal to have intelligibility, both a speaker and a listener must be involved (Lehiste & Peterson, 1959). Hence, because both speech production and speech perception are involved, distinctly more complexity is implied than is suggested by the use of superficially related terminology, such as articulation, recognisability, identifiability, and discriminability, which do not necessarily pertain to speech communication, consider meaning, or take full account of the listener.

Numerous factors determine this "communicative effectiveness". In the main, these are the social context, message content, the stimulus signal and the medium used for signal transmission, the speaker and his speech mechanism, and the characteristics of the listener. Speech intelligibility is employed by numerous disciplines (e.g. speech pathology, audiology, and acoustical engineering), each of which places differential emphasis on these major elements of the communication process. In the research on which this paper is based, the emphasis was on speaker characteristics with an attempt being made to control all other parameters as closely as possible, so that non-speaker parameters could serve

largely as constants. Essentially, this paper seeks to determine optimal message content in order to measure intelligibility in a valid fashion.

The outstanding feature of speech intelligibility is its performance as an overall index of speech performance (e.g. Yorkston and Beukelman, 1981). As such, it supersedes several related criteria and models which capture a more limited scope. These include qualitative, perceptually-based tools used for differential diagnosis, (e.g. Darley, Aronson & Brown, 1975), the evaluation of individual components of speech production, such as defective articulation (e.g. Prather, 1960), phonation, or resonance, and models which systematically evaluate the anatomical or physiological locus of disturbance along the vocal tract, such as the "point-place system" of Rosenbek and LaPointe (1978).

The inclusive nature of the concept of intelligibility is further exemplified by its pertinence to different speech-disordered groups (e.g. the cerebral palsied, alaryngeal speakers, cases of congenital orofacial malformations, among numerous others), despite the varying nature of the pathological elements of the speech production process. The concept of intelligibility is therefore sufficiently flexible to house a range of speech production variables, varying in combination and degree. It is thereby possible for each clinical population to bring to research its associated symptomatological milieu and still be investigated under the broad umbrella of intelligibility.

The potential information offered by intelligibility data is diverse, depending on both task selection and on the level of analysis undertaken: the more detailed the analysis, the richer and more versatile the applications of the data. In the literature, the analysis and presentation of intelligibility data assume a variety of forms:

1. Simple percentages of intelligibility reflecting the number of discrete units perceived correctly.

2. Analysis of perception-production confusions to form matrices (e.g. Nichols, 1976).

3. Analysis of the distance between produced and perceived phonemes (in words) in terms of distinctive features: manner, place or voicing differences.

4. Breakdown into analysis of vowel and consonant intelligibility, once the basic word intelligibility scores have been computed.

5. The determination of the patholect for a particular clinical population, or the pattern of phonemic confusions for a particular clinical group.

6. Combination of intelligibility measures with other measures such as speech rate, for example "Intelligible Words per Minute" (IWPM) and "Unintelligible Words per Minute" (UWPM) — Yorkston and Beukelman (1981).

7. Description of auditory or perceptual characteristics of the speech.

8. Development of a classification system for recognition of different groups demonstrating a particular speech disorder.

9. Development of an intelligibility measure which reflects severity of involvement such as Shriberg and Kwiatkowski's (1982) Percentage Consonants Correct (PCC), which is, however, defined as "a measure of articulatory proficiency".

Methods of assessment of surgically-treated oral cancer patients apparently sample the range of procedures generally employed in the examination of intelligibility in English-speaking pathological populations. The range of methods described in current and older research is extensive. However, whereas older research glosses informally through accounts of intelligibility, current research appears to aim at greater qualitative and quantitative specificity,

with certain intelligibility materials even being designed for particular clinical populations and the ranges of severity within them.

Standardised word lists frequently constitute the materials of speech intelligibility assessment, e.g. the CID W.22 phonetically balanced (PB) word lists (Hirsh, Davis, Silverman, Reynolds, Eldert & Benson, 1952), as employed in numerous studies (e.g. Skelly, 1973); the Consonant-Syllable Nucleus-Consonant words (Lehiste and Peterson, 1959), as selected and adapted by Tikofsky (1970), for example, for use with dysarthrics; the Fairbanks (1958) test of Phonemic Differentiation (a "Rhyme" Test), as used by Kipfmueller and Prins (1971), for example; the word lists of Black (1957), as used by Yorkston and Beukelman (1981), for example; and Moses' (1969) monosyllabic word lists (as cited by Nichols, 1976). Standardised sentence materials (e.g. the CID "Everyday Sentences") have also been utilised in examining the construct and criterion validity of various intelligibility procedures (Schiavetti, Metz and Sitler, 1981).

Finally, standardised phonetically balanced passages of reading, such as "My Grandfather", "The Rainbow Passage" and "Arthur the Rat", (Fairbanks, 1960), have been employed as elicitation material for intelligibility measurement (e.g. Platt, Andrews, Young and Neilson, 1978). However, the use of read material introduces a prerequisite of patient literacy, which was inappropriate in the research concerned. A further batch of materials includes those designed for specific clinical populations, such as the glossal and labial word lists for surgically-treated oral cancer patients (e.g. Skelly, 1973). In contrast, other research methods are individualistic from the viewpoint of the researcher, for example, the use of read sentences from early reading books in the case of deaf school-leavers (Kyle, Conrad, McKenzie, Morris & Weiskrantz, 1978), picture description (Markides, 1978), and spontaneous speech samples (Weiss, 1978, cited by Schmidt, 1984). Under the latter circumstances, the properties of the spoken material are clearly far less stringently controlled.

As mentioned above, no similar spectrum of formalised materials exists in the languages under consideration. Nonetheless, within the above range, certain themes and issues pertaining to the choice and characteristics of materials recur with remarkable regularity, thereby illustrating the origins of useful criteria for devising appropriate intelligibility measures. These may be categorised in terms of three key components:

A. The composition of speech materials, which takes into account the message to be communicated, its length, complexity, and spontaneity.

B. The form of response required of the listener, in order that he may register his reaction to or understanding of the message, either by written or spoken means.

C. The choice of general procedural characteristics influencing the reliability and validity of the assessment, such as the manner in which stimuli are presented, and the selection of judges.

The first component, the composition of spoken materials, is the chief area of interest in the present paper. The second component extends beyond the focus selected for the present discussion. Only isolated aspects of the third component are relevant here: irrespective of the nature of the materials that are selected, or the manner in which the listener responds to the signal, the mass of methodological details pertaining to stimulus presentation and listener characteristics is largely independent of the language of the speaker and thus warrants routine consideration. Such factors

include the decision to pre-record the speech stimuli or to present these live, whether to use the same stimuli repeatedly, the selection of suitable carrier phrases, and details of judge selection and training. Certain aspects of judge selection are, however, incorporated in the discussion below.

KEY CONSIDERATIONS IN DEVISING APPROPRIATE MATERIALS

A. COMPOSITION OF SPEECH MATERIALS

l. UTTERANCE LENGTH

While single words regularly form the basis of speech intelligibility scores, researchers frequently comment that single-word performance does not permit the evaluation of several critical parameters of speech, such as the effects of juncture, rhythm and stress patterns, and rate control (e.g. Griggs, 1958). Furthermore, the addition of context requires less fine discriminations of the listener (Miller, Heise & Lichten, 1951). As such, there appears to be a demand for the development of formal materials suitable for studying the intelligibility of connected speech and its intrinsic prosodic properties. Towards meeting this need, Schiavetti, Sitler, Metz and Houde (1983) recently established two formulae for calculating contextual speech intelligibility on the basis of single-word intelligibility scores.

In spite of the above-mentioned criticism, Nichols (1976) reports that excellent correlations exist between PB scores and sentence intelligibility scores for esophageal speakers: ". . . hence, word intelligibility measures may be used as estimates of connected speech abilities with confidence". Hodson and Paden (1982) cite research with phonologically-impaired children demonstrating that essentially the same processes were revealed by single-word elicitation procedures as by both delayed sentence imitations, and by connected speech samples. This work therefore plays down, to some extent, the presumed effects of utterance length. Yorkston and Beukelman (1978) support the above findings noting that mean intelligibility scores for sentences were not different from scores derived from single-word tests. However, for transcription tasks, there was an interaction between severity and intelligibility scores on sentences versus words, that is, the most intelligible speakers tended to score higher on sentence transcriptions, while the least intelligible speakers received higher scores on single words. The same researchers also found that various measurement techniques, including both sentences and single words, tended to rank speakers similarly. Beukelman and Yorkston (1979) confirmed the close relationship between both single-word and sentence intelligibility, and the amount of information transferred between a speaker and a listener. Interestingly enough, Platt, Andrews, Young and Neilson (1978) concluded that intelligibility of PBs was an excellent measure for assessing speech competence after finding good correlations with assessments of the recognisability of individual phonemes.

It is clear, however, that the above correlations are mostly calculated on the basis of standardised English materials. As such, extrapolation of these results to other languages is uncertain. In summary then, the first issue encountered was whether to establish speech intelligibility levels based on single words and/or connected speech.

In view of the property of context, it is logical that connected speech would automatically reflect the semantic, morphological and phonological characteristics of a language. Therefore, the following discussion pertains chiefly to the development of single-word intelligibility materials, although a range of sociolinguistic characteristics of connected speech is highlighted simultaneously.

Furthermore, this review proceeds from overriding linguistic properties of the five languages, largely of a general, sociolinguistic nature — with implications at a semantic level, and progresses towards the enumeration of more specific, phonetic, phonological and morphological characteristics. All of these considerations affect the choice of individual word items.

2. WORD FAMILIARITY/FREQUENCY

A chief dimension along which word item selection for formal lists may be restricted, is that of vocabulary or work familiarity (e.g. CID W.22 word lists). Schultz (1964) examines the criterion of high familiarity of CID W.22 words, analysing the relationship between stimulus and response familiarity, and concludes that although the required educational level of the listener is lowered, certain unique patterns and problems arise (Schultz, 1964). Most researchers still agree, however, that the greater the frequency of the word, the more likely it is of being intelligible (e.g. Black 1952). This phenomenon has been explained in terms of "set" or "expectancy" (ibid. 1952).

In English, word familiarity is usually controlled by consulting Thorndike's list of word frequencies (1932, cited by Hirsh et al. 1952) or that of Thorndike and Lorge (1952, cited by Lehiste and Peterson, 1959).

In the African languages under consideration, only one study, of a most preliminary nature, has investigated word frequency per se (viz. Gowlett & Rassmann, 1979), in one language. This study considers the 367 most common words in Southern Sotho, while Griesel (1979) lists common Zulu vocabulary items for instruction of learners of the language. Such research provides cursory guidelines regarding word frequency in African languages, and gives rough clues as to culturally relevant items in other Bantu languages. It appeared therefore that word familiarity was a significant consideration but its implementation would be constrained by the paucity of formal indices of word frequency. As such, this criterion would have to be borne in mind informally when formulating materials.

Several interrelated phenomena further complicate the application of the principle of word familiarity to South-Eastern Bantu languages, exerting their influences predominantly on the choice of vocabulary items appropriate for single-word intelligibility testing. These include the factors of multilingualism, vocabulary differences between urban and rural speakers of a language, mutual intelligibility in the face of dialectal variation, and the prevalence of borrowed words.

a. MULTILINGUALISM

A prime factor colouring the "purity" of the Bantu languages spoken by the subjects of the research under consideration, that of the judges, as well as native speakers who were consulted, is the phenomenon of multilingualism (e.g. Wilkes, 1978). This is a normal condition among black South Africans, particularly in the industrial cities and border areas, such as the Western Transkei, where Xhosa and Southern Sotho co-exist, and Eastern Transvaal, where Tsonga, Pedi and Zulu overlap (Lanham, 1978). In fact, in such multilingual communities, a "pure" Northern or Southern Sotho, Tswana, Zulu, or Xhosa speaker has long since disappeared, although a pure form of his language is still used in certain rural areas (Wilkes, 1978). Lanham (1978) cites the example that it is expected that an Nguni speaker will have a good control of a Sotho language if a substantial proportion of the immediate speech community speaks Sotho.

One subject of the research under discussion, a nursing sister, illustrates an apparently normal occurrence. She was raised and educated speaking Southern Sotho, and married a Swazi speaker. After undergoing her professional training in Zulu, she moved to Port Elizabeth for a year and had to learn to speak Xhosa. She currently lives in a Zulu-speaking community in an East Rand urban area, delivers lectures in Zulu, speaks English at home to her husband, converses with other Sotho speakers in Zulu, but feels that her Zulu may be marred by a trace of Sotho "intonation". She also feels that after twenty-five years of speaking Zulu predominantly, her Zulu is better than her Sotho. This history presents a difficult decision in terms of the choice of language for administration of intelligibility tests. Finally, the inherent subjectivity of autobiographical reporting must be considered.

Subjects also claimed that whilst living in their townships surrounding Johannesburg, they had found themselves combining snatches of several languages. This would appear directly attributable to the multilingual milieu in such areas. Hence, it seems that in addition to possession of a language medium for education or rearing, there is an urbanisation of original, "pure" forms and the development of "city dialects".

> The degree of this mixing, the levels on which it occurs, to what extent it takes place systematically and whether or not it differs from speaker to speaker and occasion to occasion, are but a few of the questions of which the answers can only be guessed at, for the simple reason that no researcher has as yet made any attempt to investigate these fields with their wealth of sociolinguistic phenomena (Wilkes, 1978: 110).

While on the one hand, there is the urban black demonstrating an extensive multilingual repertoire, there is on the other, the rural black with his associated vocabulary. In the study under consideration, the source of subjects covered both rural and urban areas, while judges were likely to be urbanised. As such, it was important to take both elements into account in compiling materials, by locating shared linguistic features and by avoiding both extremes as much as possible, so that all items were acceptable to both types of speakers.

b. DIALECTAL VARIATION

While all standards are to some extent idealisations, persistent difficulties arise in devising materials due to the prevalence of dialectal variation in the South-Eastern Bantu languages.

Although more than a dozen Bantu dialects have been investigated, many others have hardly been described. Far more than half of the dialects of which the Nguni and Sotho languages are composed, are as yet undescribed (Wilkes, 1978).

> To what extent these dialects are (still) characterised by deviant or distinctive systems, or have had to make way for other (more dominant) systems, will become clear only when a comprehensive survey of all the South African Bantu language dialects is carried out (Wilkes, 1978).

In the practice of compiling word lists, it was difficult at times to know whether the native speaker being consulted was in fact speaking an unstandardised dialect or not. Furthermore, native speakers frequently disagree on lexical issues, and therefore, without actually consulting a vast range of native speakers, which was beyond the scope of the study, the information provided to the researcher had to be treated cautiously.

c. BORROWED WORDS

A further factor contributing to the difficulty of item selection for word lists is the influence of English and Afrikaans. In many dictionaries numerous entries representing such influences, are labelled "borrowed words". The large English-Afrikaans vocabulary of Sotho and the phonological principles by which loan words have been incorporated, have been described by Kunene (1963, cited by Lanham, 1978).

Van Wyk (1978) notes that English words were borrowed in the "educational, technical, commercial and industrial spheres", i.e. in those spheres where English is used extensively by blacks. Afrikaans loans on the other hand are drawn from practical spheres, such as clothing, farming, labour, household implements and foodstuffs. The ratio between English and Afrikaans loan words varies in the different languages, depending upon the proximity to either predominantly Afrikaans or English-speaking communities (Van Wyk, 1978).

In drawing up suitable lists of word items, the familiarity of borrowed words to the range of speakers of the relevant languages would be inestimable. Thus, unless these are extremely common, these should be omitted wherever possible in preference to more indigenous words. Conversely, in the urban areas speakers of non-standard varieties of the South-Eastern Bantu languages would find certain standard forms beyond even their passive lexical knowledge. It would therefore seem desirable to avoid selecting word items characterising either extreme, i.e. borrowed or esoteric indigenous words.

The methodological implications of the above factors for word familiarity complicate the task of devising single-word materials considerably. Their recognition is nonetheless helpful in constraining the selection of word items along appropriate dimensions.

It is pertinent too to consider the control of word familiarity in direct relation to both listeners (judges) and speakers (subjects). For both groups it would be desirable that the language used for test administration is that spoken in the home during childhood, as well as that comprising the vernacular during schooling. Furthermore, in order to avoid the uncontrollable complications resulting from speaker unfamiliarity with word items, an auditory model for imitation should be provided by a proficient speaker of the language who is also familiar with the test materials.

The problematic influence of word familiarity, compounded by the fact that the subjects of the present research did not all speak the same language, could arguably be obviated through the use of a single, cross-linguistic task comprising nonsense words, additionally spanning a progression in phonetic complexity. Such a task would thereby tap phone recognisability, or, viewed differently, articulatory efficacy. However,
(i) such a task would be of limited clinical significance — the production of phonemic distinctions is of greater interest than the capacity for articulatory agility — which is linguistically meaningless;
(ii) it is most probably that only through production of linguistically meaningful units (i.e. words) that it can be established whether target phonemes are recognisable, in spite of phonetic distortion or allophonic variation;
(iii) linguistic variety within the subject sample was not sufficiently problematic that articulatory capabilities of subjects and inferences regarding articulatory functioning would be irretrievable.

3. WORD LENGTH

Single-word intelligibility materials in English have mostly com-

prised monosyllables, as is evident from the original PB-50's (Egan, 1948), CID W.22 PB word lists (Hirsh et al. 1952) and the Fairbanks Rhyme Test (Fairbanks, 1958). This is perhaps due to the well-documented finding that the greater the number of syllables contained in an English word the more intelligible the word is likely to be (e.g. Black, 1952).

In the relevant African languages, monosyllables are comparatively infrequent. Therefore extracting the criterion of fewest possible syllables per word is perhaps inappropriate, as the effects of multisyllabic words on intelligibility may not be the same as in English. In the Nguni and Sotho languages, the criterion of mono-syllabicity is virtually impossible to conform to as trisyllables and bisyllables, respectively, comprise the canonical forms of lexical items, while monosyllables are comparatively infrequent (Cole, 1955). (The canonical forms of lexical entries for Nguni verbs are frequently bisyllabic when constituting singular imperatives, but these items contain some undesirable redundancy, as is discussed later). Monosyllables are therefore insufficiently representative of the relevant languages to constitute an admissible criterion for the word structure of single-word intelligibility materials. Nonetheless, the reasoning behind the use of monosyllabic English words perhaps implies that words should have as few syllables as possible.

In the absence of verb prefixal and suffixal formatives, verb stems in the Nguni and Sotho languages are very commonly bisyllabic (CVCV shape). In the Nguni languages, this bisyllabic word structure represents the singular imperative form and some pronouns. In the Sotho languages, nouns also have a CVCV structure, whereas Nguni nouns mostly have a VCVCV structure due to the noun class prefix always beginning with a vowel. There are very few productive noun suffixes in the South-Eastern Bantu languages.

The Bantu languages are also syllabic tone languages (i.e. each syllable in a word has its particular tone value). The pattern of the syllable is mostly open, taking a CV form (consonant/consonant combination + vowel), but sometimes there is a no word-initial consonant (e.g. "a-ba-ntu": people — Zulu). In the Sotho languages it is not uncommon to have a CVC syllable shape, where the final consonant is the syllabic nasal, /ɔ/ . The fact that the final consonant always has the same identity, is possibly a source of phonemic redundancy.

Taking into account the present considerations regarding word structure, it is apparent that Xhosa and Zulu vocabulary items of VCVCV form comprise nouns, while in the Sotho languages, the CVCV form demonstrates grammatical variety, including nouns, verbs and pronouns. From a grammatical point of view therefore the nature of bisyllabic Nguni words is more restricted than that of Sotho, and the exclusive selection of singular verb imperatives would add considerable redundancy to the stimuli in terms of both tonal cues and the identity of the final vowel, which would always be /a/. However, the difference is not seen as significant because the phonological properties of the different word classes are homogeneous in major aspects, and are therefore of no specific interest.

The presence of syllabic liquids and nasals in the Sotho languages (e.g. /r/ and /m/) results in several words of a CV structure, which are bisyllabic, and words of a CVCV structure, which are trisyllabic (e.g. "rre" : father, "mmini" : dancer — Tswana). In

view of the fact that such syllable structures are characteristic, these two forms would have to be included in the respective Sotho word lists.

4. PHONETIC BALANCE

The principle of phonetic balance, which probably embodies the most stringent form of the notion of "phonetic composition representative of the language" (Egan, 1948), dictates that the relative frequencies of occurrence of component speech sounds in a language, that is, their distribution in normal speech, should be reflected in any word list. In English PB materials, the phonetic composition (balancing) is based on Dewey's frequency count of English sounds in a sample of 100000 words (Dewey, 1923, cited by Egan, 1948).

Tobias (1964) states that phonetic balance is not a meaningful criterion for construction of word lists. He offers the rationale that Dewey's phonetic analysis of the relative frequency of English speech sounds was almost completely of written material. Tobias also observed "startling differences" in phonetic structure between any one PB list and any other. He states that although Egan's original PB-50 lists are not well-balanced phonetically, they are diagnostically superior to the CID W.22 lists in which the balance is far better. He concludes that since discrimination-testing based upon the PB-50 lists is useful, phonetic balance could not be playing much of a role. Nonetheless, the suggestion to consider the frequency of particular phonemes when devising materials, is pertinent.

No indices of phoneme frequency are known to exist in the relevant African languages. It would seem desirable nonetheless to represent all the phonemes in each language in order to access the manner in which these were articulated by subjects and perceived by judges. An arbitrary decision would be necessary regarding the number of times each phoneme should appear in the relevant word list.

Table 1: Consonant and vowel phonemes of five South-Eastern Bantu languages (*) combined with certain phonetic variants due to constitution of a cluster or nasal compound (C) or dialect (D). Abbreviations: Z. - Zulu; X. - Xhosa; N.S. - Northern Sotho; S.S. - Southern Sotho; T. -Tswana.

			Z.	X.	N.S.	S.S.	T. l.
1.	**BILABIALS**						
	/p'/	– ejective stop	•	•	•	•	•
	/pʰ/	– aspirated stop	•	•	•	•	•
	/b̤/	– murmured stop	•	•			
	/b/	– voiced stop	C	C	D	•	•
	/ɓ/	– implosive stop	•	•			
	/m/	– nasal	•	•	•	•	•
	/m̤/	– murmured nasal	D	•			
	/w/	– glide	•	•	•	•	•
	/ɸ/	– voiceless fricative			•		•
	/β/	– voiced fricative			•		D
2.	**LABIODENTALS**						
	/f/	– voiceless fricative	•	•	D	•	D
	/v/	– voiced fricative	•	•			
	[ɸf']	– ejective affricate	C	C			
	[βv]	– voiced affricate	C	C			

		Z.	X.	N.S.	S.S.	T.
3. ALVEOLARS						
/t'/	– ejective stop	•	•	•	•	•
/th/	– aspirated stop	•	•	•	•	•
/ʥ/	– murmured stop	•	•			
/d/	– voiced stop	C	C	•	•	
/s/	– voiceless fricative	•	•	•	•	•
/z/	– voiced fricative	•	•			
/ɬ/	– lateral fricative	•	•	•	•	
/ɮ/	– voiced lateral fricative	•	•			
/n/	– nasal	•	•	•	•	•
/nɦ/	– murmured nasal			•		
/r/	– trill			•	•	•
/l/	– lateral liquid	•	•	•	•	•
/tɬ/	– ejective lateral stop	C	C	•	•	•
/tlʰ/	– aspirated lateral stop			•	•	•
/dɮ/	– voiced lateral affricate	C	C			
/ts'/	– ejective affricate	•	•	•	•	•
/tsʰ/	– aspirated affricate		•	•	•	•
4. LABIO-ALVEOLARS						
/ɸs/	– fricative			•		
/ps'/	– ejective affricate			•		
/psʰ/	– aspirated "double"			•		
5. ALVEOPALATALS						
/ʃ/	– voiceless fricative	•	•	•	•	•
/ʒ/	– voiced fricative			•		
/ɲ/	– nasal	•	•	•	•	•
/ɲʰ/	– murmured nasal			•		
/j/	– glide	•	•	•	•	•
/tʃʰ/	– aspirated affricate			•	•	•
/tʃ'/	– ejective affricate	•	•	•	•	•
/dʒ/	– murmured affricate	•	•			
/dʒ/	– voiced affricate	C	C		•	
6. PALATALS						
/c'/	– ejective stop			•		
/cʰ/	– aspirated stop			•		
[ɲc']	– voiceless stop			C		
/ɟ/	– murmured stop			•		
[nɟ]	– voiced stop			C		
7. LABIOPALATALS						
/rʃ/	– fricative		D	•		D
/ɸʃ/	– voiceless fricative		•			
/βʒ/	– voiced fricative		•			
/pʃ'/	– ejective "double"		•	•		D
/pʃʰ/	– aspirated "double"		•	•		D
/bʒ/	– aspirated "double"			•		D
8. VELARS						
/k'/	– ejective stop	•	•	•	•	
/kʰ/	– aspirated stop	•	•	•	•	•
/x/	– voiceless fricative	D	•	D	•	
/ɣ/	– voiced fricative			•	•	
/ŋ/	– nasal	DC	•	•	•	•
/kx'/	– ejective affricate	D	•		•	
/kxʰ/	– aspirated affricate			•		
/kɬ'/	– ejective lateral affricate		•			
/g̥/	– murmured stop	•	•			
[g]	– voiced stop	C	C			
9. GLOTTALS						
/h/	– voiceless fricative	•	•			•
/ɦ/	– voiced fricative	•	•	•	•	

		Z.	X.	N.S.	S.S.	T.
10. CLICKS						
/ǀ/	– voiceless dental	•	•			
/ǀʰ/	– aspirated dental	•	•			
/ⁿǀ/	– nasalised dental	•	•			
/ǀg/	– delayed voice dental	•	•			
/ⁿ/g/	– fully voiced dental	•	•			
/nk//	– preceding nasal+voiceless	C	•			
/ǃ/	– voiceless alveopalatal	•	•		•	
/ǃʰ/	– aspirated alveopalatal	•	•		•	
/nǃ/	– nasalised alveopalatal	•	•		•	
/ǃg/	– delayed voice alveopalatal	•	•			
/ŋǃg/	– fully voiced alveopalatal	•	•			
/ŋkǃ/	– preceding nasal+voiceless	C	•			
/ǁ/	– voiceless lateral	•	•			
/ǁʰ/	– aspirated lateral	•	•			
/ǁg/	– delayed voice lateral	•	•			
/nǁ/	– nasalised lateral	•	•			
/ŋ/ǁg/	– fully voiced lateral	•	•			
/ŋkǁ/	– preceding nasal+voiceless	C	•			
11. VOWELS						
/a/		•	•	•	•	•
/ɛ/		•	•	•	•	•
/e/				•	•	•
/i/		•	•	•	•	•
/ɔ/		•	•	•	•	•
/o/				•	•	•
/u/		•	•	•	•	•

Table 1 contains the phonemic inventories of Zulu, Xhosa, Northern Sotho, Southern Sotho and Tswana, based on the works of Brown (1971), Cole (1955), Doke (1931), Doke and Mofokeng (1957), Jordan (1966), Khumalo (1981), Mabille and Dieterlen (1961), Ziervogel et al. (1967), Ziervogel, Louw and Taljaard (1981), and Ziervogel and Mokgokong (1975). These inventories are presented in order to identify the phonemic constituents of the South-Eastern Bantu languages and to informally observe differences from English. To capture subtle phonetic differences between ostensibly similar articulations belonging to different languages (e.g. /b/ in Zulu as compared to the Sotho languages), finer phonetic specifications are incorporated within the phonemic description (viz. /b̥/ versus /b/: murmured versus voiced /b/).

The purpose of depicting certain phonetic variants, comprising members of consonant clusters or nasal compounds, is that clusters are particularly complex and therefore most taxing phonetically — quite conceivably affecting intelligibility. For this reason they would add an additional dimension of complexity to intelligibility word lists. In Table 1 elements of clusters or nasal compounds are marked with a "C".

Dialectal variants are incorporated in Table 1 too, primarily to mark alternative correct productions which could be misconstrued as errors, and for the sake of completeness. These are marked with a "D". In conducting a single-word intelligibility task, dialectal variation would need to be taken into account and should not incur penalty. For example, in Northern Sotho, the labio-alveolar fricative, /ɸs/, may also be produced as /ts/, or /h/, or /f/)Ziervogel et al. 1967).

Certain segments appear only within ideophones in the canonical forms cited above. An ideophone is an onomatopoeic word form with its own morphology, phonology and prosodic rules (Kunene, 1978). In view of these properties, the controversial definition of ideophones (Wilkes, 1978), and their frequent appearance within a particular grammatical structure, such as "ho re . . ." (Southern Sotho), from which it may be indivisible, it would seem unwise to consider ideophones as word items. This view would hold irrespective of whether an ideophone contained a required phoneme.

The extensive range of consonants in each of the above languages compared to English, has implications for the length of word lists as it would be desirable to include all consonants more than once for reliability purposes.

Comparison of the phonemes of Zulu, Xhosa, Southern Sotho, Northern Sotho and Tswana, reveals language-specific trends (Table 1): the vast repertoire of clicks, voiced and voiceless fricatives, /ɬ/ and /ʒ/, and murmured forms of /b/, /d/, and /g/, are characteristic of Zulu and Xhosa. Xhosa also has an extended range of palatal phonemes, depicted orthographically as "ty" and "dy", and the ejected velar affricate /kx'/. In addition many Zulu fricatives are pronounced as affricates in Xhosa, for example, "inhloko" is "intloko", and "insimu" is pronounced "intsimi".

Particular to the Sotho group of languages are the alveolar trill, /r/, the aspirated lateral stop, /tlh/, the voiced alveopalatal fricative, /ʒ/, and the labio-palatal "double" phonemes (affricate-like, generally characterised by two virtually simultaneous, non-adjacent places of articulation), /tʃ/, /pʃ'/, /pʃh/, and /bʒ/. Members of the latter group tend to be dialectal in Tswana. Characteristic of Northern Sotho are the labio-alveolar phonemes, /ts/, /ps'/ and /psh/

Tswana contains marked dialectal variation, which influences the production of alveolar and alveopalatal affricates, and also leads to the non-lingual voiceless fricative also being produced as either /f/ or /h/.

All five languages display phonemic aspiration, ejection of consonants, and the palatal nasal phoneme, /ɲ/. As a group these therefore show a variety of airstream mechanisms in speech: glottalic ingressive and egressive, velaric, as well as pulmonic airstream mechanisms.

Where vowel phonemes are concerned, South-Eastern Bantu languages have five to seven pure vowels as a rule, no central vowels, and no diphthongs. The Nguni languages, Xhosa and Zulu, both have five basic vowel phonemes with one variant each of /e/ and /o/, acting in complementary distribution as a result of adjacent vowel influence. The Sotho languages, Southern Sotho, Northern Sotho and Tswana, have seven basic vowels and four additional phonetic variants (Ziervogel et al. 1967).

B. RESPONSE FORMATS

The formalised materials discussed above require that the listener's response consists of repetition, transcription, written completion of a word with one letter, or completion of multiple-choice response formats. It would appear though that transcription or stimulus repetition serves as the closest means of reflecting the listener's actual perceptions. Although multiple-choice formats have excellent quantifiability and recognised usefulness, analysis of such tasks indicates that these may well test identifiability rather than intelligibility. The listener's "perceptions" are structured to fit a particular framework and real perceptions may be ignored. Furthermore it has been demonstrated that multiple-choice response formats may be graded in difficulty by systematically altering the information provided to the judges, while keeping the stimulus constant (Yorkston & Beukelman, 1980). In this instance there is an inverse relationship between the number of selection options and intelligibility (ibid.). The influential effects of various response formats with specified options suggest that these may contaminate the results of intelligibility tests and are best avoided.

Where test materials comprise connected speech, rating scales are commonly used to capture gradations of speech intelligibility. These clearly demand a different type of subjectivity to that of the procedures described previously, in that they rely on appraisals rather than the listener's actual comprehension of speech. However, the appropriateness of different rating scales deserves judicious consideration to ensure the selection of valid indices of speech intelligibility (cf. Schiavetti, Metz & Sitler, 1981).

Many of the issues concerning response formats are examined by Yorkston and Beukelman (1978). These researchers conclude that it may be beneficial to take advantage of the task hierarchy that apparently exists among quantification procedures, instead of relying on a single measurement technique to quantify speech across the entire performance range. However, this suggestion would appear more suited to clinical practice than research, as in the case of the latter, a standard methodology is necessarily implemented.

THE NATURE OF REDUNDANCY

The foregoing discussion reveals various factors which could increase the redundancy of the speech signal during intelligibility testing. These include the offer of options in identifying stimulus words, the use of linguistic context, the exclusive selection of singular verb imperatives, and an increase in the number of syllables per stimulus word (certainly for English). However, redundancy in a word intelligibility task is an undesirable feature in that it meddles with the attempt to measure "absolute" intelligibility. Meyerson, Johnson and Weitzman (1980) comment on the contribution of redundancy to the intelligibility glossectomees, reporting a 50 per cent discrepancy in intelligibility scores based on single words versus connected speech.

In the present South-Eastern Bantu languages, there is likely to be some degree of redundancy in single words existing independently of that contained in connected speech, largely due to the multisyllabic, tonal nature of words in these languages. As such redundancy is potentially introduced at the word level in the form of semantic and grammatical tonal cues. These properties, in conjunction with fairly consistent syllable shapes and sequences, conceivably provide supplementary cues to single-word intelligibility stimuli.

On a morphological level, furthermore, many single words in the Bantu languages are polymorphic, with all prefixes and some suffixes showing grammatical tone. In this regard, it is noteworthy that in Zulu, for example, noun prefixes are composed of only three vowels and seven consonants (Westphal, 1973). This limited range could possibly aid the listener's decision when the noun stem is doubtful. On the other hand, noun stems are so varied that it is uncertain whether the class prefix effectively contributes any redundancy to the speech signal, in spite of its tonal characteristics and phonetic composition. It would seem, nonetheless, that if grammatical tone does add redundancy to work items, this would operate in the case of nouns predominantly.

In attempting to eliminate all the above-mentioned potential sources of redundancy in a word intelligibility task, the syllable composition of the words would probably need to be restricted to being as short but as representative as possible, the noun class prefix would have to be limited to only one syllable, and the use of options in the response format would be rejected.

CONCLUSION

A detailed account has been presented of paramount considerations in resolving the issue of task and material selection

for the measurement of intelligibility in five South-Eastern Bantu languages. The final outcome of the effort to attain maximally valid measures was therefore arrived at under the following restrictive circumstances:

1. the absence of a Dewey-type index of relative phoneme frequency;
2. the absence of a Thorndike-Lorge-type index of word frequency for languages other than Southern Sotho;
3. the absence of standardised passages of reading;
4. the paucity of intelligibility materials for English-speaking glossectomees to act as guidelines for the development of materials in African languages.

The decision was made to couple two complementary tasks: a single-word task, which may be viewed as a "molecular-intensive" or detailed analytical measure, while rating of a spontaneous speech task comprises a "molar-extensive" or global measure (Hollenbeck, 1978), and may be regarded as a "molar taxonomy", as it combines a "a number of features, actions, directions, and objects of behaviour" (Sackett, 1978: 25). This decision was determined by three factors which receive elaboration below: the specific research objectives, the emergency of two distinctive genres of intelligibility measures, and the limitations of any single measure of intelligibility in isolation.

Firstly, in considering the purpose of the research, there was dual interest in "how well speech was understood", which indexes overall speech effectiveness, as well as in specific error patterns. It seems logical that there be an underlying commonality to both processes and one would predict that the number of errors relates closely to the understandability of contextual speech. However, two discrete tasks were deemed necessary: it could not be assumed that the percentage word intelligibility based on unstandardised materials would accurately parallel the level of spontaneous speech intelligibility; neither could it be assumed that a word list, assembled on the basis of strict criteria such as phoneme position and syllable structure, would reflect the properties of everyday speech and vocabulary. The use of spontaneous speech samples was therefore important for the criterion validation of an unstandardised work intelligibility task.

Hence, *a word intelligibility task* incorporating the phonetico-phonological properties of the relevant language was desirable in that

1. phonemes could be included in a controlled and structured manner;
2. the lack of context normally provided by syntax would allow evaluation of each phoneme in a minimally redundant form;
3. a numerically specific index of the percentage of intelligible words could be computed;
4. words are the work-horse of intelligibility materials in English, and serve as highly accessible units of speech for a researcher who is not a fluent speaker of a foreign language.

Similarly, *a spontaneous speech task* was desirable in that

1. ratings of performance on such a task could tackle the construct of speech intelligibility directly as everyday connected speech would be typified, providing a reasonable approximation of the normal communication process;
2. the task promotes the linguistic style and vocabulary of the subject and thereby captures a congruent communicative whole. Isolated words, in contrast, are in danger of falling peripheral to either the judge's or the subject's vocabulary, despite careful item selection.

The particular method whereby spontaneous speech samples may be evaluated, constitutes a separate methodological decision which lies outside the scope of the present paper.

The lists of single words in Zulu, Xhosa, Northern Sotho, Southern Sotho and Tswana, appear in Appendixes 1-5. As far as possible, these were formulated and items selected according to the following criteria:

1. Vocabulary items should be familiar to both rural and urban speakers of the relevant language.
2. The word structure should be highly representative of the particular language in question. A scan of common vocabulary items in Nguni and Sotho languages, combined with the notion of shortest word having least redundancy, suggested that it was most appropriate to include *bisyllables* in the *Sotho* languages where the simplest uninflected nouns and verbs have a CVCV (nasal) structure, and *trisyllables* in the *Nguni* languages where nouns of a VCVCV structure predominate because of the pre-prefix. Although CVCV verb imperatives are readily available in the Nguni languages, the final V is always /a/ which acts to increase the redundancy of stimuli in that the final vowel is always given.
3. All consonant phonemes in each language should be included twice in the list, once as the first consonant in a word and secondly, in an intervocalic position.
4. Within the scope of these criteria, the number of items presented to the judges was restricted to as few as possible by eliminating the least satisfactory items. This represented an attempt to increase both reliability and validity. The least satisfactory items in the research were those of doubtful conversational familiarity. It was hoped that the remaining items would constitute sufficiently long tests and that these would be more reliable, comprehensive and valid than lists that would have been any shorter.
5. Rigorous balancing of vowel phonemes was not undertaken due to the stringency of primary requirements already mentioned. An attempt was made, however, to keep the frequency of different vowel phonemes equivalent within each word list.

Secondly, the above exposition of intelligibility and related issues reveals two distinguishable categories of assessment methods: the first category, comprising formalised procedures, displays a certain stringency of both item selection (the maximal units of which are sentences), and procedural design (which facilitates quantification and error analysis). However, English procedures of this nature are at times of questionable validity, in terms of the definition of intelligibility provided earlier in this paper, as these could be more accurately regarded as exercises in stimulus discriminability. In the case of South-Eastern Bantu languages, materials of this nature could be formulated through the informal application of principles such as word familiarity, word length, and phonetic balance.

In contrast, less formalised procedures, in that either the material or the assessment procedure itself is irregular, perhaps represent more valid appraisals of intelligibility. These procedures generally have, as a minimal unit, the sentence, and usually consist of either read or spoken samples of connected speech. Hence, these demonstrate high face validity in representing overall speech behaviour, which is of prime interest. However, in this instance, the validity of the listener's task or tool of judgment may be questionable in relation to the construct of speech intelligibility.

These observations suggest that both formal and less formal procedures have merits and demerits, and probably represent complementary entities, which are most effective in unison.

Thirdly, as demonstrated by English materials, although the above range of intelligibility measures and procedures is vast, in most cases, only a portion of overall speech performance is

captured by a single measure, which furthermore, cannot be employed to describe performance across the entire severity range: as all measures have both a ceiling and a floor effect, these are sensitive to performance changes in only a limited range.

These limitations underscore the strength of any single measure of intelligibility in research which is combined with at least one other intelligibility task, or the event of intelligibility comprising only one measure within a battery of measures of speech production, where such a battery also incorporates acoustic, articulatory, and physiological studies. Additional measures then serve as concurrent validation procedures.

If "the observer's perception and subsequent judgment represents the final validity for the identification and measurement of disordered speech" (Young and Downs, 1968: 6), the present paper comprises a preliminary step in the direction of reflecting this criterion, that is, intelligibility, among speakers of South-Eastern Bantu languages.

ACKNOWLEDGEMENTS

APPENDICES

APPENDIX 1 : ZULU WORD LIST

ORTHOGRAPHY	PHONEMIC TRANSCRIPTION	GLOSS
idada	/idada/	– duck
umunwe	/umunwɛ/	– a finger
ungcede	/uŋ/gɛdɛ/	– common little bird
unyawo	/uɲawɔ/	– leg
inxele	/in//ɛlɛ/	– left-handed person
isifo	/isifɔ/	– sickness
itiye	/it'iɟɛ/	– tea
incwadi	/in/wadi/	– a book
inyoni	/iɲɔni/	– bird
umhambi	/umhambi/	– traveller
ugogo	/uɡɔɡɔ /	– grandmother
ithanga	/it'aɲa/	– pumpkin
ingxoxo	/iŋ//gɔ//ɔ/	– a conversation
iqhude	/iʘhudɛ/	– a cock
ihhashi	/ihaʃi/	– horse
indlovu	/indjɔvu/	– elephant
imvubu	/imɨvubu/	– hippo
inhlanhla	/intɬ'antɬ'a/	– luck
uzipho	/uziphɔ/	– nail
ihlombe	/iɬɔmbɛ/	– shoulder
uhala	/uhala/	– a cotton thread
ibhasi	/ibasi/	– bus
ikati	/ik'at'i/	– cat
utshani	/utʃ'ani/	– grass
imfundo	/imɸfundɔ/	– education
ichibi	/i/hibi/	– a pond
ikhehla	/ikhɛɬa/	– a man beginning to go grey
ukudla	/uk'uɠa/	– food

ORTHOGRAPHY	PHONEMIC TRANSCRIPTION	GLOSS
inhlanzi	/intɬ'andzi/	– fish
igazi	/igazi/	– blood
ixhegu	/i//hɛgu/	– old man
iqanda	/iʘanda/	– an egg
umeqo	/umɛʘɔ/	– a jump
izinyo	/iziɲɔ/	– tooth
insimu	/ints'imu/	– field
uqhotho	/uʘhɔthɔ/	– shrivelled thing; homeless person
ufudu	/ufudu/	– tortoise
iviki	/ivik'i/	– week
iphepha	/iphɛpha/	– paper
iconsi	/i/ɔnts'i/	– drop of liquid
unpompi	/umpɔmp'i/	– a tap
igeja	/igɛdʒa/	– a plough
izimvu	/iziɨvu/	– sheep
umgqomo	/umɡɔmɔ/	– barrel; drum; "round person"
imbuzi	/imbuzi/	– goat
iwashi	/iwaʃi/	– a watch
indlebe	/indʒlɛbɛ/	– ear
idlelo	/iɠɛlɔ/	– pasture
induku	/induk'u/	– a stick
umshado	/umʃadɔ/	– a wedding
inantshi	/inantʃ'i/	– naartjie fruit
ilanga	/ilaɲa/	– sun; day
inzule	/indzulɛ/	– type of indigenous cow
ijaha	/idʒaha/	– strapping fellow
amakha	/amakha/	– perfume, scent
ingiqi	/iŋiʘi/	– lazy person
isiklabhu	/isikɬabu/	– sheep
igceke	/i/gɛk'ɛ/	– courtyard
ingqondo	/iŋɡɔndɔ/	– mind; brain
uxamu	/u//amu/	– leguaan
igxathu	/i//gathu/	– stride (n)
ingxangxa	/iŋ//gaŋ//ga/	– a green-striped frog
igxolo	/i//gɔlɔ/	– bark of tree
icici	/i/i/i/	– earring
ipapa	/ip'ap'a/	– porridge

APPENDIX 2 : XHOSA WORD LIST

ORTHOGRAPHY	PHONEMIC TRANSCRIPTION	GLOSS
inzala	/indzalu/	– progeny; interest (on capital)
indlovu	/indʒɔvu/	– elephant
indyebo	/indʒɛbɔ/	– treasure; plenty
ityhefu	/ichhfu/	– poison (n)
intyelo	/inc'rlɔ/	– information
intlahla	/intɬ'aɬa/	– shiny, glossy appearance
ibhokwe	/ibɔkwi/	– goat
irafu	/ixafu/	– tax, hut-tax, poll tax
igronya	/iɟɔɲa/	– sack-cloth, coarse cloth; sack
ikrele	/ikx'ɛlɛ/	– stabbing assegai, sword, sickle
ihashe	/ihaʃɛ/	– horse, mount; abcess
imvubu	/imɨvubu/	– hippopotamus
indoda	/indɔda/	– man, husband
intsimi	/ints'imi/	– arable field, garden
imfene	/imɸf'ɛnɛ/	– baboon
amanzi	/amandzi/	– water
ikhaya	/ikhaja/	– home, residence, dwelling, domicile
ityiphu	/ic'iphu/	– domestic fowl
isidlo	/isiɠɔ/	– meal, feast
ikratshi	/ikx'atʃ'i/	– arrogance
ithanga	/it'aɲa/	– pumpkin; thigh; outpasture; outfarm, outkraal
ubisi	/ubisi/	– (sweet) milk

ORTHOGRAPHY	PHONEMIC TRANSCRIPTION	GLOSS
icici	/i/i/i/	– something circular: earring; small group
ixesha	/i//ɛ ʃa/	– time, period; watch, clock
ucango	/u/aŋɔ/	– door (not a doorway); cell in a honeycomb
incoko	/in/ɔk'ɔ/	– conversation
ixhego	/i/ʰɛgɔ/	– old man
igqira	/i!gixa/	– doctor, medicine-man, witch-doctor
ingxowa	/iŋ//gɔwa/	– bag, pouch, sack, pocket
umfundi	/umɸɛ'undi/	– pupil, scholar, reader, disciple, student
izonka	/izɔŋk'a/	– loaves of bread
iphepha	/ipʰɛpʰa/	– paper; page
uluvo	/uluvɔ/	– feeling, sensation; view, opinion; impression
ingcambu	/iŋ/gambu/	– root
impompo	/imp'ɔmp'ɔ/	– pump
iqhosha	/i!ʰɔʃa/	– button, buckle; coin; seashell
ubhaqo	/ubaʔɔ/	– discovery
ibuzi	/iɓuzi/	– rat
iceba	/i/ɛɓa/	– councillor; splinter
ijokwe	/idʒɔk'wɛ/	– jar
ugcado	/u/gadɔ/	– a roast
uvuyo	/uvujɔ/	– joy, gladness, rejoicing
iwatshi	/iwatʃ'i/	– watch, clock
ihlobo	/iɬɔɓɔ/	– summer
itshintshi	/itʃ'intʃ'i/	– change (n)
utolo	/ut'ɔlɔ/	– arrow
idama	/idama/	– dam, reservoir
inyosi	/iɲɔsi/	– bee
isingci	/isiŋcgi/	– mane
ushenxo	/uʃɛn//ɔ/	– leeway
udladla	/uɖaɖa/	– granary
ingwiqi	/iŋwi!i/	– a gulp, swallow
igatya	/igac'a/	– clause; branch
umhambi	/umɦambi/	– traveller
iqanda	/i!anda/	– egg; large bead
ichibi	/i/ʰiɦi/	– pool, pond, lake
igxalaba	/i//galaɓa/	– shoulder, shoulder-blade
inxele	/in//ɛlɛ/	– left hand; left-handed person
umnqwazi	/umn!wazi/	– cap, hat
ingwanqwa	/in!wanʔa/	– step
icangci	/i/aŋgi/	– piece of corrugated iron; metal sheet
inkcazo	/ink/azɔ/	– memorandum; explanation
uncipho	/un/ipʰɔ/	– decline, decrease
inkxwaleko	/ink//walɛk'ɔ/	– misery
umngquho	/umŋk!uʃɔ/	– samp
ingqumbo	/iŋ!gumbo/	– anger
injini	/indʒini/	– engine
ijaji	/idʒadʒi/	– judge
umgcini	/um/gini/	– one who keeps
umgodi	/umgɔdi/	– deep excavation, mine; a hole
ingozi	/ingɔzi/	– danger; misfortune, accident, injury
inkqu	/iŋk!u/	– reality
unoqho	/unɔiʰɔ/	– clothes-peg
isixa	/isi//a/	– bunch; handful (of grass, corn flowers)
umgwebi	/umgwɛɓi/	– those who judge

APPENDIX 3 : NORTHERN SOTHO WORD LIST

taebe	/ts'ɛbe/	– ear
pudi	/p'udi/	– goat
dijo	/diʒɔ/	– food

ORTHOGRAPHY	PHONEMIC TRANSCRIPTION	GLOSS
noka	/nok'a/	– river
kgogo	/kx'oiɔ/	– chicken
topa	/t'ɔpa/	– pick up
toro	/tɔrɔ/	– dream; prickly pear
bjala	/βʒala/	– plant; beer
botse	/bots'e/	– beautiful
ngaka	/ŋak'a/	– doctor
mong	/mɔŋ/	– master, owner; one, other (adj.)
nyala	/ɲala/	– to marry, give dowry
thea	/tʃ'ea/	– take, receive, get hold, take on; marry
hlogo	/ɬɔlɔ/	– head
tlala	/tl'ala/	– hunger
khuta	/kʰut'a/	– hide
phiri	/pʰiri/	– hyena, wolf
motho	/motʰo/	– person
pshapsha	/pʃʰapʃʰa/	– applaud, clap
tshipi	/tʃ'ipi/	– iron; bell
tlhaba	/tlʰaba/	– slaughter, to stab a person
psinya	/ps'iɲa/	– defaecate!
holla	/ɦola/	– to cry
dinku	/diŋk'u/	– sheep
ngwana	/ŋwana/	– child
motse	/mots'e/	– village, town
nnoshi	/ɳoʃi/	– alone
tshwene	/tʃ'wene/	– baboon
mmele	/ɱele/	– body
mpa	/ɱp'a/	– stomach; skipping rope; sky between two clouds
sego	/setɔ/	– calabash
kofi	/k'ɔri/	– coffee
hwile	/ɦwile/	– has passed away; dead
fase	/fase/	– under, below, down
gohle	/ioɬe/	– everywhere
legong	/lei̯oɦ/	– wood, timber
Tshwane	/tsʰwane/	– Pretoria
leho	/lɛfɔ/	– spoon, ladle
swiri	/ɸsiri/	– lemon
maswi	/maɸai/	– milk
pholo	/pʰolo/	– ox
ngwaga	/ŋwaɣa/	– year
robja	/roβʒa/	– break, break off (passive of "roba")
monna	/moɳa/	– man
haka	/ɦaka/	– to hook on
jase	/dʒaae/	– overcoat
patshi	/patʃ'i/	– coat
wetshwe	/wetʃ'we/	– fall toward; to fail in (causative of "wela")
kgomo	/kx'omo/	– heard of cattle
lla	/la/	– cry; mourn; ring; strike (a bell) play a musical instrument; bellow; yelp; mew; whistle
pshatla	/pʃʰatl'a/	– to break (into pieces); break in (to burgle); smash
nnyane	/ɲane/	– small, little, miniature
mpheng	/ɱpʰeɦ/	– a handle
gomme	/xome/	– and; furthermore
thunya	/tʰuɲa/	– cause dust; blossom; ache; explode
kua	/kua/	– over there
sebopsa	/sebopʃ'a/	– creature
mme	/ɱe/	– my / our mother
nna	/ɳa/	– I, me
ngwe	/ŋwe/	– another
lefaega	/lefjeɣa/	– faeces of diarrhoea; a coward
ipshina	/ipʃʰina/	– enjoy, be happy

ORTHOGRAPHY	PHONEMIC TRANSCRIPTION	GLOSS
nokgwa	/nokx'wa/	– manner, custom, habit
dimpša	/dimpʃ'a/	– dogs

APPENDIX 4 : SOUTHERN SOTHO WORD LIST

ORTHOGRAPHY	PHONEMIC TRANSCRIPTION	GLOSS
pitsa	/pita'a/	– pot, vessel
buka	/buk'a/	– book
thipa	/tʰipʰa/	– knife
nama	/nama/	– meat
leino	/leino/	– tooth
koloi	/k'olɔI/	– wagon, car
kgauta	/kx'aut'a/	– gold; a big gold or silver bead
hempe	/hemp'e/	– shirt
qeto	/ǃɛt'ɔ/	– the end, conclusion; decision
tahela	/taʰela/	– to cross (a road); to cut meat; to live; to pour
ntsha	/ntsʰa/	– to take out, to send, to contribute
ntja	/ntʃ'a/	– dog; despised person; dysentry of children; very heavy stone
pjhatla	/pʃʰatl'a/	– to speak much, to tell; to break into pieces
nnete	/net'ɛ/	– truth
mmoho	/mɔhɔ/	– together; on one side
leqhwa	/leǃʰwa/	– ice
kgaba	/kx'aba/	– to be beautiful; to dress well; a spoon; to have a nice action
phiri	/pʰiri/	– hyena
mathe	/matʰe/	– saliva
ngwana	/ŋwana/	– child, infant; tooth of a baby; charm used for frightening birds away
dijo	/diʒɔ/	– food; crops
sheshe	/ʃeʃe/	– violence; type of tree
dutla	/dutl'a/	– to leak, trickle out, drip
diha	/diha/	– to cause to fall; to throw, to cast down, to put into trouble
fohla	/fɔɬa/	– to peel; to enlarge a hole
hanka	/haŋk'a/	– to walk proudly
tlatla	/tl'atl'a/	– to shine; a wooden dish (for meat)
tlhoka	/tlʰok'a/	– hardened ear-wax; to shout
shwaya	/ɬwaja/	– to prick, to sting, cause a rash
tsohle	/ta'ɔtɬe/	– all, everything
tshwepha	/tsʰwɪpʰa/	– to twist, entwine
motsho	/motsʰo/	– black
qaqa	/ǃaǃa/	– to be plain, evident
monna	/mona/	– man, husband
tjotja	/tʃ'otʃ'a/	– to continue raining
tjhella	/tʃʰɛlɔ/	– damage sustained through fire
motjhi	/motʃʰi/	– not anywhere
kgwahla	/kx'waɬa/	– to run; to become strong, firm; to shrivel up
jaka	/ʒak'a/	– to go and live in a foreign place
sitsa	/sits'a/	– to give, to grant, to favour with
madi	/madi/	– blood; beer
pjhanya	/pʃ'ana/	– to speak, to say
pjatla	/pʃ'atl'a/	– to boil well
tosa	/t'ɔaa/	– to stretch out, to raise
bjaratsa	/bʒarats'a/	– to crunch, to smash
nyorwa	/nɔrwa/	– to become thirsty
lla	/la/	– weep, cry, emit a sound, bellow
pjheha	/pʃʰɛha/	– to have diarrhoea, to be purged; to act in a cowardly manner
abjwa	/abʒwa/	– to divide, hand out, distribute
mookgo	/mɔ'kx'ɔ/	– tears (n)
hlatswa	/ɬatswa/	– to wash
lefjwa	/lefʃwa/	– to be paid

ORTHOGRAPHY	PHONEMIC TRANSCRIPTION	GLOSS
nku	/ŋk'u/	– sheep
kgafa	/kx'afa/	– tax, hut-tax-duties
nna	/na/	– I, myself; to be; continually
mme	/mɛ/	– mother of; and, also, indeed
tshwara	/tsʰwara/	– to seize, to get hold of, to capture
kgomo	/kx'ɔmo/	– a herd of cattle
yaka	/jak'a/	– it seemed that
repha	/rɛpʰa/	– to become loose, old

APPENDIX 5 : TSWANA WORD LIST

ORTHOGRAPHY	PHONEMIC TRANSCRIPTION	GLOSS
mantswe	/manta'we/	– words
mollo	/molɔ/	– fire
kgopa	/kx'op'a/	– snail; to trip up, stumble, offend, vex, displease
tlase	/tl'ase/	– down
podi	/p'odi/	– a goat
taie	/ta'iɛ/	– locust
tshimo	/tsʰimo/	– a garden
thuto	/tʰut'ɔ/	– lesson, education
ruri	/ruri/	– true
koko	/k'ok'o/	– grandmother
moagi	/moaxi/	– a builder
ngaka	/ŋak'a/	– a doctor
nyala	/ɲala/	– to marry
rwele	/rwele/	– has worn
jala	/dʒala/	– plant;
tshupa	/taʰupa/	– weavil
lwana	/lwana/	– fight, quarrel, strive with each other
tshweu	/taʰwɛu/	– white
tshwara	/tsʰwara/	– hold
gagwe	/gagwe/	– his, hers
nkgwana	/ŋkx'wona/	– a water pot, calabash
dinku	/diŋku/	– sheep
yaalo	/jaalɔ/	– like that
mowa	/mowa/	– air
yona	/jɔna/	– it
leswe	/leawɛ/	– dirty, nasty
puo	/puɔ/	– speech
tau	/t'au/	– lion
kobo	/kobo/	– a kaross; blanket
sejo	/aedʒɔ/	– food
nama	/nama/	– meat
rre	/rɛ/	– father, my father
gotlhe	/xɔtlʰe/	– entirely, all
pitsi	/p'ita'i/	– a horse; a zebra
tshipi	/tsʰip'i/	– iron, metal
khudu	/kʰudu/	– tortoise
mme	/mɛ/	– my mother
phutha	/pʰutʰa/	– to gather, collect
tlhaba	/tlʰaba/	– to slaughter, stab
kgopho	/kx'opʰo/	– a small bush with edible fruit
phepha	/pʰɛpʰa/	– clean
fofa	/fofa/	– fly!
wesi	/wɛsi/	– own; alone
tefo	/t'efɔ/	– payment
senya	/aena/	– spoil!
rragwe	/raxwe/	– his father
mmidi	/midi/	– mealie
nnye	/ɲe/	– little
nnetlane	/netl'ane/	– something
nkga	/ŋkx'a/	– to emit a smell
tlhwaya (tsebe)	/tlʰhwaja/	– to listen carefully
lla	/la/	– cry

ORTHOGRAPHY	PHONEMIC TRANSCRIPTION	GLOSS
lwantsha	/lwantsʰa/	– cause to quarrel or strive with each other
lotšwa	/lotʃ'wa/	– be required, demanded, asked for
mpho	/mpʰɔ/	– gift
sekhi	/sekʰi/	– a species of thorny bush
supa	/supa/	– to show, point; seven
seba	/seba/	– to whisper, to backbite
aga	/axa/	– to build; live, dwell
fitlha	/fitlʰa/	– to arrive; to bury, hide
kgakge	/kx'akx'e/	– wonder, astonishment
mašwi	/maʃwi/	– milk, sweet milk
tsoma	/tsʼoma/	– to hunt
dikgwa	/dikx'wa/	– clumps of bush
mmini	/mmini/	– dancer
bonnye	/bonne/	– smaller
setšhaba	/setʃʰaba/	– nation
tlhatsa	/tlʰatsʼa/	– vomit
gotlha	/xotlʰa/	– rub a surface
monya	/mɔnɔ/	– dew; mist

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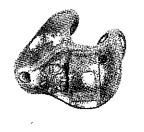
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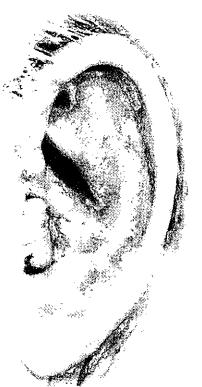Schiavetti, N., Sitler, R.W., Metz, D.E. and Houde, R.A. Prediction of contextual speech intelligibility from isolated

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