The measurement of Sudanese intelligibility to native and Dutch listeners of English

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Abstract

The primary focus of this paper is to investigate intelligibility problems facing Sudanese university learners of English. The whole work was done on the basis of a segmental analysis of vowels, singleton consonants, and consonant clusters of English so as to explore the types of perception errors made in the areas under concern.

Ten Sudanese-Arabic learners of English as foreign language (EFL) were recorded. On the basis of a pilot test, one male speaker was then selected as the optimally representative EFL speaker. The same materials were recorded from a single male native speaker of RP English.

In a subsequent perception test Dutch EFL listeners were presented lists of words that included vowels, single and cluster consonants, as well as a list of SPIN sentences (SPIN = Speech Perception in Noise test, developed by Kalikov, Stevens and Elliot, 1997 [J. Acoust. Soc. Am. 61, 1337-1351] read alternatively by the Sudanese and the native British speaker. The single-item (word) stimuli were constructed on the basis of the Modified Rhyme Test (MRT) but with a few potential improvements. The MRT is less time consuming than other diagnostic intelligibility tests and provides reliable results

even with small groups of 10 to 20 listeners. The information obtained can be analyzed by confusion matrices that will in turn show how different phonemes are misidentified. Thus, the MRT helps localize the learning difficulties.

Data showed that the Dutch listeners made more perception errors (specifically on English central and back vowels) when read by the Sudanese speaker than when read by the RP control speaker. Dutch listeners found the native speaker of English more intelligible than the Sudanese speaker.

Due to the set-up of the experiment, we can separate the confusions on the part of the Dutch EFL listeners into two components: (i) confusions due to the fact that the Dutch listeners are not aware of certain phonemic contrasts in English (such as the difference between bed and bad or between full and fool) and (ii) confusion due to incorrect pronunciation of the English sounds by the Sudanese EFL speaker.

1. Introduction

Learning a second language speech can often be strongly described as a phonological representations dependent process where L1 influences L2. This assumption is detectable when ESL/EFL learners attempt to distinguish between e.g., English minimal pairs like *bet/bait, cat/ cart, din/den, sin /thin, half/ halve, bed/ bet, wit/wet, worse/ worth, pea /bee, peer/ pair* etc**.** In this task, learners exert an effort to produce the intended speech sound correctly, although most of them fail, after all. One reason why the learners face problems such as these is the discrepancy of the perceptual representations of phonemes exists between

L1 and L2. Previous studies revealed that Japanese EFL learners have perception and production problem of the English /ρ~ λ/ in words like *lot vs. rot* [2]. In a more related study, Arabic learners of English have difficulty distinguishing /Δ, ζ, T, σ/ because English fricatives are softer than Arabic counterparts [3]. Linguists are very much concerned with measuring these types of errors, which manifest in the performance of the second or foreign language learners. A test that measures speech production issues such as these (in words like *lake* vs. *rake)* and accuracy of L2 sounds is segmental intelligibility measurement. When L2 speech sounds are recognized correctly to native speakers this constitutes evidence that the L2 production possesses distinction categories. However, failure is also a useful proof, which provides insights that help to predict the nature and the causes of intelligibility problems [3]. This study adopts a segmental intelligibility measurement of the speech sounds produced by Sudanese university EFL learners (native speakers of English included in this study but as a control group only). It attempts to account for the extent to which linguistic elements can impede the intelligibility of these speaker groups when Dutch listeners of English assess them. Important point is that the involvement of Dutch listeners of English as a judgment group was intended to provide different feedback. This is because the dichotomy of native/non-native speaker proved to be less valuable, particularly when the use of a two-sided concept of intelligibility has recently been found to be more effective [4, 5]. In other words, as a cross case analysis which included Dutch listeners of English, native RP speakers as control groups and Sudanese EFL learners as a tested group, the study is expected to provide more evidence of intelligibility problems under investigation.

Arguably, Sudanese EFL learners frequently make a variation of production errors of vowels, consonants and clusters of English. Substitutions of English vowels are observed in words such as *pot, put, pat coat*, *palm*, *warm*, *flute*, etc. It is assumed that these types of errors occur because the speakers are not familiar with a large number of vowels such as those of English. Similar errors are also observed in the performance of these subjects approaching English clustered consonants. For example, a vowel sound is usually inserted before (prothesis) or between (anaptyxis) the English cluster members such as *flow sprint*, *special* and so on. Doing this, speakers aim to achieve perceptible pronunciation as consonant clusters are absent from Arabic phonemic inventory. Differences of phonological representations between English and the Sudanese learners' L1 (Arabic) make the issue concerned more difficult.

This study reports the results of English speech sounds produced by Sudanese EFL learners contrasted to those of native English speakers, assessed auditorily by the Dutch listeners of English.

2. Objective

Objective of the study is to find experimental evidence for the causes of speech intelligibility problems experienced by Sudanese university speakers of English based on the assessments of Dutch listeners of English. The data obtained can also help understand and draw cognitive insights into the nature and causes of pronunciation problems the learners face.

3. Subjects

The subjects involved in these experiments came from different linguistic backgrounds. They include Sudanese university learners of English, British speakers of English and Dutch students preparing for bachelor or master degrees in various fields. In the following sections, I will provide more background information on the various speaker groups.

3.1 Sudanese speakers (university EFL learners)

These are ten Sudanese University students of English at Gadarif University in Sudan. The subjects involved in these experiments specialize in English language teaching (TEFL) and have already spent six semesters of study. During the period of study, which extends for four years, the students attend three courses in the field of pronunciation: (i) an introduction to phonetics, (ii) phonology and (iii) practical phonetics delivered in three following semesters, besides two classes in English listening skills that usually take place at semester one and three. The Arabic language is the mother-tongue language for all the students, whilst English is treated as a foreign language (not a second language) the learning of which starts at the basic level in the fifth year and continues at secondary schools for three years. The English lessons obtained at such stages vary between 5 and 6 hours per week, but which treat English as a school subject that teaches basic principles of English in a traditional way of language teaching. One of these ten students was involved in the perception tests as a speaker of Sudanese accented English. This speaker was asked to read out a list of English stimulus items which include vowels, single and cluster consonants, besides SPIN sentences.

The Sudanese model speaker was selected by means of a quality sound test from among a number of 11 Sudanese speakers of English. The sound quality test was operated online and candidates of different nationalities were invited to listen to the test and provide scores to each speaker by clicking on one of the grade options provided. Assessment of the speakers' sound quality depended on the computation of the total mean of the results of each speaker. Finally, we chose the speaker with the average mean as a representative subject.

3.2 Native speakers of English

The subject herein is a native speaker of English (RP accent) who was involved in the perception tests as a model speaker of English. Such a subject was asked to read out stimulus items which included vowels, single and cluster consonants of English, besides SPIN sentences.

3.3 Dutch Listeners of English

Participants here included ten Dutch students who were preparing for bachelor and master degrees in various fields of study at Leiden University. These subjects took part in the perception tests as listeners only.

3.3.1 Learning problems of English speech sounds

Despite the fact that linguistically English and Dutch languages are strongly related, Dutch listeners of English face a variation of learning problems of English vowel and consonants.

Both English and Dutch languages have a large number of vowels. Moreover, both English and Dutch vowels fall into three categories (i) checked vowels, (ii) free steady-state vowels and (iii) diphthongal phenomenon, which classify them as having something in common. However, there are differences in Dutch vowel system. For example, Dutch vowel inventory includes a set of combination of free vowel sequences that do not exist in English. These vowels include /ε˥Y/ which presents a combination of /ε˥/ and /Y/ (6 and Mees 1999). Differences as such make the learning of some English vowels difficult to Dutch listeners.

Dutch listeners confuse the English /Θ and /ε/ due to the assumption that Dutch vowel inventory has only /ε/ in this area of vowel space which is positioned between the two English vowels /Θ and /ε/. Similarly, the English diphthong /αI/ is also misidentified as /εI/ probably because it is closer to the English /εI/ than /αI/. The major cause of these perception errors is the influence of L1 vowel inventory [(1).] Inability of Dutch listeners to distinguish between the English vowels /Θ and /ε/ in minimal pairs such *cattle/ kettle* is described as an impact of pseudo – homophones that accompanies minimal pairs such as the previously mentioned ones, the occurrence of which depends on word activation process. A robust effect of such a phenomenon occurs where Dutch listeners respond faster to items presented in an earlier task [(1).]

Dutch and English consonants in most respects are similar; however, they show some differences due to language specificity. The English fricatives form major perception and articulation problems for Dutch learners. There is a problem with the articulation of /Δ/ and /T/, whilst pairs such as /σ ~ T/ and /Δ~ δ/ undergo substitutions. Most of Dutch speakers of English have learnt some English in primary and secondary school so they already know the /T~σ/ contrast. However, language reality shows that these speakers have difficulty in distinguishing between the English fricatives /T~σ/ [(6)]. This is probably because the dental fricative /T/ is absent from Dutch consonant inventory. Related studies attribute this learning problem to several factors such as phonemic differences between Dutch L1 inventory and English. However, [(7)] Heeren was reported that the identification and discrimination of British-English /T~σ/ of the Dutch listeners improved after training which is consistent with results from earlier training studies. That is, results show that trained listeners performed better in the post-test than in the pre-test and in several respects they also did better than the untrained control group. The improvement in their performance excluded acquired similarity, but acquired distinctiveness was not found exclusively at the phoneme boundary. Furthermore, control listeners, who received no training, also improved by simply performing the tests twice in pre-test and post-test due to experience of the control group in the design of a phoneme training study. Other learning problems of English consonants the substation of the substitution of /ϖ~ω/ is due to orthographical effect of Dutch languages (6).

3.3.2 Motivation to test Dutch listeners of English

Intelligibility was evaluated auditorily by Dutch listeners of English due to several factors:

- Dutch listeners and Sudanese learners of English met at important points such as age and education level. Both subjects were university students preparing for bachelor degree, thus, all of them ranged at similar age stage. These characteristics have important influence on second language learning
- Other factors related to language proficiency such as phonetic distinctions, training of L2 speech and everyday exposure of English could affect intelligibility rate (8,9). Dutch listeners enjoyed a good command of English both in *read speech* and *spontaneous speech* a feature which enables non-native listeners to make relatively effective judgments and less understanding errors.
- Dutch listeners were assumed unfamiliar subjects with Sudanese-accented Arabic English. Thus, they were labelled as naive listeners (10) a characteristic, which is considered effective determinant of speech intelligibility.

- Technically, the involvement of Dutch listeners as non-native speakers of English in intelligibility assessment as across group listener strategy that worked along with native listeners of English (the same test has been done by native British and American listeners of English) was intended to provide different feedback.

4. Intelligibility tests used

Intelligible speech is defined as speech that is understood by native speakers [11]. This means that speech intelligibility is principally a hearer-based construct that depends on interaction in an appropriate context involving the apprehension of the message between the listener and the speaker. It is also possible to refer to speech intelligibility as any successful communication that involves both native and non-native speakers of English because the final goal of such speech is understandability. Since listeners of this study are expected to have incorrect conception of English speech sounds, focus will be on examining vowels, consonants and consonant clusters. This is because they form the basic sound knowledge of English language and because the assessment of whether speech is intelligible or not is attributed to segmental factors; more than 50% of speech intelligibility is accounted for on the basis of speech sounds [12]. Moreover, pronunciation includes all a learner needs to do to be intelligible [13].

The Modified Rhyme Test (MRT) was used in the experiments. The MRT is considered to be the most accurate and reliable measure of intelligibility [14]. Speech intelligibility measures involve word identification tasks in a closed-set of four-items where the listeners are asked to select the response they think the speaker intended. The score is the number of correctly responded to items. Test items normally target phonemes, multi-phonemes or words. Phonemes refer to vowels and single consonants, whilst multi-phonemes refer to consonant clusters. The formal assessments of phonemes and multi-phonemes interpret the responses as either intelligible or unintelligible; put in figures, a score of (close to) 100% is interpreted as completely intelligible performance [(15)]. Word intelligibility, on the other hand, was determined by the recognition of final words embedded in short redundant SPIN sentences. SPIN is an abbreviation of 'Speech in Noise' Test (16, Stevens and Elliott 1977, 20 and van Heuven 2003, 20 2007), a perception test measures listener's perception abilities. Measurement is based on a recognition task of twenty-five words embedded in meaningful and highly predictable sentences, as in *She wore her broken arm in a sling* (target word underlined).

Listeners write down the final word that they think they heard in each sentence. This part of the SPIN test proved to be efficient at assessing speech recognition abilities (Rhebergen and Versfeld 2005). Although the listeners' performance is primarily quantified in terms of number of whole words correctly recognized, partially correct answers are also important since they give information about the perception of phonemes in onset, nucleus and coda position.

5. Test battery

5.1 Material and Overall structure

The experimental stimuli include four tests. These are (i) a vowel test, which is composed of minimal quartets including short and long vowels as well as diphthongs, (ii) single consonants in either onset or coda position and (iii) consonant clusters in onset or coda position. These target sounds were embedded in meaningful C*VC* words (where C* stands for one to three consonants). The fourth test comprised 25 sentences taken from the high-predictability set included in the SPIN (Speech in Noise) test [16]. These are short everyday sentences in which the sentence-final target word is made highly predictable from the earlier words in the sentence, as in *She wore her broken arm in a sling* (target word underlined). Word stimuli in the first three tests were embedded in a fixed carrier sentence [*say…again*], which insured a fixed intonation with a rise-fall accent on the target word. The vowel and the single consonant tests contained items on each individual vowel or consonant phoneme in the RP inventory. Moreover, the consonant test targeted all the consonants in onset position and in coda position. For the cluster test, the number of test items had to be limited as the total inventory of onset and coda clusters is very large; including all the clusters would have been too demanding on the subjects. Nine onset and eight coda clusters were selected that represent problems to Sudanese-Arabic learners of English [17, 18]. All items in the tests were chosen such that they occurred in dense lexical neighbourhoods, i.e. there should be many words in English that differ from the test item only in the target sounds. For instance, the vowel /I/ was tested in the word pit, since the /p_t/ consonant frame can also be filled in by many other vowels, as in *peat, pet, pat, pot, part, port, put, putt* and *pout*. These so-called lexical neighbours, differing from the target word in only the identity of the test sound, make up the pool of possible distracters (alternatives) in the construction of the MRT test. When selecting the three distracters needed for each test items, we preferably selected lexical neighbours that differ from the target in only one distinctive feature. For the target pit, we selected alternatives with vowels that differed from /I/ in just one vowel feature, i.e. pet (differing in height), put (differing in backness) and pot. The latter alternative differs from the target in both height and backness; we preferred this to the one-feature difference in peat (or Pete) as we decided to exclude proper names and low-frequency alternatives as much as possible. The full set of test items is included in the Appendix.

5.2 Recordings

The stimulus sentences were typed on paper sheets (one sheet for each test), and then read by a male Sudanese EFL leaner and native speaker of RP English. Recordings took place in a sound-treated room. The speaker's voice was digitally recorded (44.1 KHz, 16 bits) through a high-quality swan-neck Sennheiser HSP4 microphone. The speakers were instructed to inhale before uttering the next sentence. The target words were excerpted from their spoken context using a high-resolution digital waveform editor Praat [(19)]. Target words were cut at zero-crossings to avoid clicks at onset and offset. Target words and SPIN sentences were then recorded onto Audio CD in seven tracks. The first track contained two practice trials for the vowel test and was followed by track 2, which contained the 19 test vowel items. Tracks 3 and 4 contained the practice and test trials for the single consonant tests and tracks 5 and 6 contained the cluster items. Track 7 comprised the 25 SPIN sentences with no practice items. In the single consonant and cluster tests, trials targeting onsets preceded the items targeting codas. Other than that, the order of the trials within each part of the test battery was random. Trials were separated by a 5-second silent interval. After every tenth trial, a short beep was recorded, to help the listeners keep track on their answer sheets.

5.3 Perception test procedure

The stimuli were presented over loudspeakers in a small classroom that seated ten listeners. Subjects were given standardized written instructions and received a set of answer sheets that listed four alternatives for each test item. They were instructed for each trial to decide which of the four possibilities listed on their answer sheet they had just heard on the CD. They had to tick exactly one box for each trial and were told to gamble in case of doubt. Alternatives were listed in conventional English orthography. In the final test (SPIN), subjects were instructed to write down only the last word of each sentence that was presented to them. There were short breaks between tests and between presenting the practice items and test trials. Subjects could ask for clarification during these breaks in case the written instructions were not clear to them. We will now present the results of the test battery in four sections, one for each test. Each section will first outline the structural differences between the sounds in the source language, Sudanese Arabic (SA), and in the target language, RP English. Such comparisons may help understand why certain English sounds are difficult for Sudanese learners and others are not.

6. Overall results

6.1 Vowels

6.1.1 Vowel results

We will now present the results of the test battery in four sections, one for each test. Each section will first outline the structural differences between the sounds in the source language, Sudanese Arabic (SA) and in the target language, RP English. Such comparisons may help understand why certain English sounds are difficult for Sudanese learners and others are not.

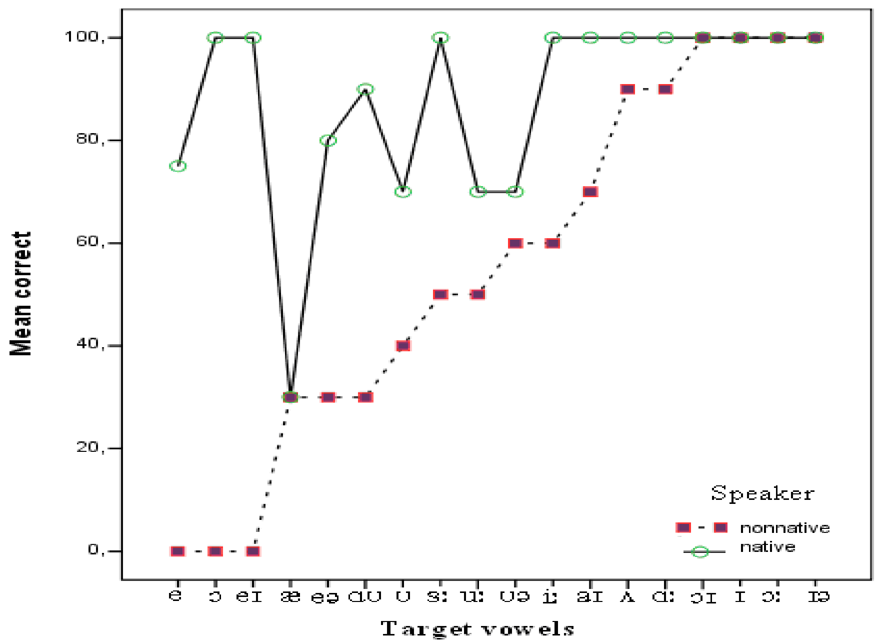


Figure .1 Mean percent correct vowel identification English vowels by ten Dutch listeners. The vowels were spoken by a Sudanese ('non-native') and a native speaker English.

Results in figure (1) include the means of a perception test of English vowels responded to by ten Dutch listeners. Dutch listeners had low scores in perceiving /Θ, AY, ε↔/ produced by Sudanese speakers of English, whilst they totally misidentified the short vowels /ε, □/ and the diphthong /εI/. However, they made few errors in recognizing the vowels /I⌉, ∈⌉, Y, υ⌉, Y↔/ and even less errors were made in the perception of /A⌉/and /αI/. These types of perception errors, which cover all short and long vowels as well as diphthongs, indicate that English vowels spoken by Sudanese university students of English are less intelligible to Dutch listeners. Several factors may cause these perception problems, which will be discussed later. It is noteworthy that Dutch listeners have shown perfect understanding of /I, □⎤, □I, I↔/.

On the other hand, means in figure.1 show that Dutch listeners have a higher perception rate of English vowels spoken by native speakers of English than that of the Sudanese EFL learners; overall perception rate is 88% against 50% when the listeners were exposed to Sudanese speakers. More specifically, figure.1 shows that English vowels /℘, ∈⎤, □,I⎤, A⎤, εI, αI, I↔, □⎤, □I/ were perfectly perceived and few errors were made in the recognition of /Y, υ⎤, Y↔, ε↔, AY/, whilst the front short vowel /ε/ was hardly recognized. Interestingly, the correct scores of the listeners at issue are strikingly different; their perception is low with Sudanese speakers and high with the native speakers of English. The error patterns of the listeners with the two speaker groups represent interesting parallel cases.

Furthermore, Tables .1 and .2 are confusion matrices. They provide a numerical account of the correct scores and the confusions made by Dutch listeners when they heard English vowels spoken by the Sudanese EFL learners and the native English speakers, respectively. The tables show the correct scores along the diagonal in the tables with the problematic vowels in the off-diagonal cells. Table.1 includes the perception data of vowels spoken by Sudanese speakers, whilst table.2 includes the data of vowels spoken by native speakers of English. A number of three items (Ii 20%, no 10%, or 10%) which stand as confused responses of /εI, ℘, ε↔/ but which do not match any target items are omitted from the table.1 to make it easy to read. In table.1 the vowels /I⌉, Y, υ⌉, ε, ∈⌉, E↔, Θ, Y↔/ form the most problematic areas, whilst in table .2 /Y, υ⌉, ε, ε↔, Θ/ were highly confused vowels. The tables also show that listeners misidentify the vowel /AY/ as /↔Y/ (↔Y: does not match any target item) with both speakers.

Table.1. Confusion matrix of 18 English stimulus vowels and diphthongs spoken by Sudanese EFL speakers (in the rows) perceived by ten Dutch listeners (in the columns). Correct responses are on the main diagonal, indicated in bold face. (Confusions ≥ 3 are indicated in grey-shaded cells).

Target	Responses																		
	℘	∈⌉	A⌉	Θ	AY	αI	ε	ε↔	εI	I	ι⌉	I↔	□	□⌉	□I	Y	υ⌉	Y↔	↔υ
℘	**9**																		
∈⌉		**5**										4		1					
A⌉			**9**											1					
Θ	4			**3**			1									2			
AY					**3**														7
αI						**7**			2	1									
ε							**0**			7	3								
ε↔		6						**3**											
εI							5		**0**	3									
I										**10**									
ι⌉										4	**6**								
I↔												**10**							
□	2												**0**			8			
□⌉														**10**					
□I															**10**				
Y																**4**	6		
υ⌉																5	**5**		
Y↔															4			**6**	

Table .2 Confusion matrix of 18 English stimulus vowels and diphthongs spoken by native speakers of English (in the rows) perceived by ten Dutch listeners (in the columns). Correct responses are on the main diagonal, indicated in bold face. (confusions ≥ 3 are indicated in grey-shaded cells).

Target	Responses																		
	℘	∈⌉	A⌉	Θ	AY	αI	ε	ε↔	εI	I	I⌉	I↔	□	□⌉	□I	Y	υ⌉	Y↔	υ↔
℘	**10**																		
∈⌉		**10**																	
A⌉			**10**																
Θ				**10**															
AY					**9**														1
αI						**10**													
ε				3			**7**												
ε↔		2						**8**											
εI									**10**										
I										**10**									
I⌉											**10**								
I↔												**10**							
□													**10**						
□⌉														**10**					
□I															**10**				
Y																**7**	3		
υ⌉																3	**7**		
Y↔														3				**7**	

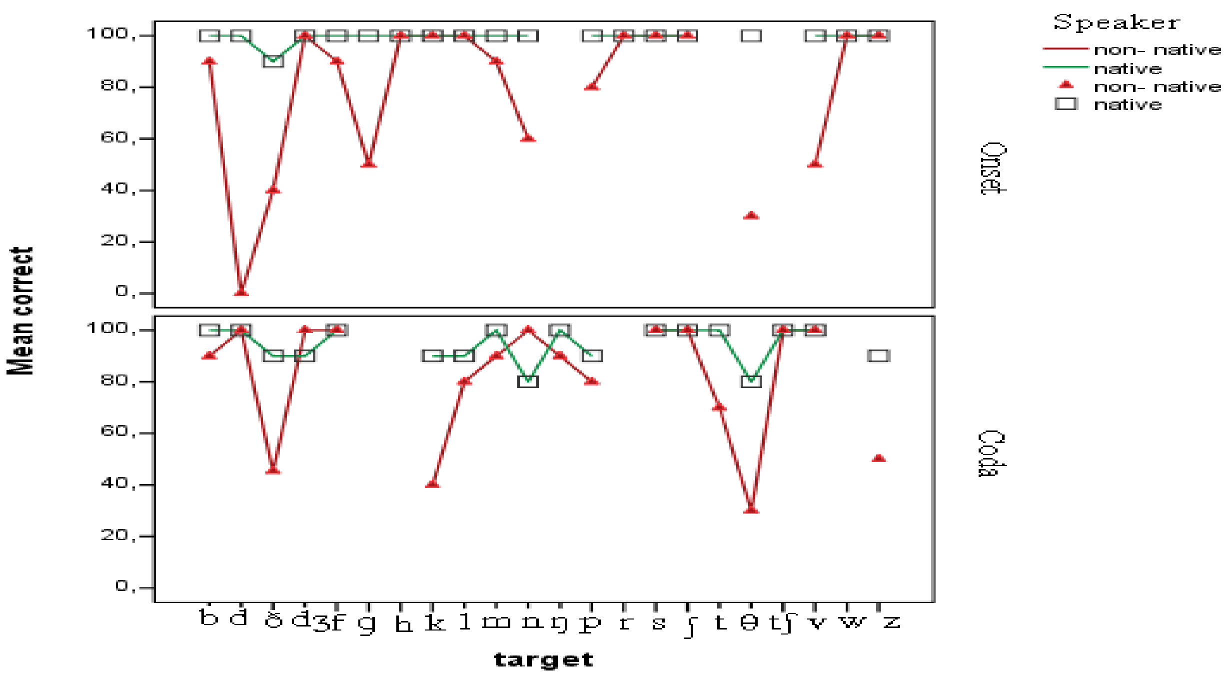
6.1.2 Discussion and Conclusions

More perception errors of English vowels were made by Dutch listeners when they heard Sudanese EFL learners. There were interchangeable substitutions of the English vowels /Y ~ υ⌉, I~ I⌉, Θ ~ ε/ might be attributed to the influence of the listeners' L1 vowel inventory. [6] confirmed that English tense and lax pair /Y ~ υ⌉/ and /Θ ~ ε/ are the most difficult vowel sounds for Dutch listeners/ speakers to imitate. Confusions of these English vowel pairs frequently occur because there are no similar vowel sounds in their L1. Interestingly, [20] Wang reported similar results where Dutch listeners repeatedly confuse /I~I⌉, Y ~υ⌉, Θ ~ε/ when they listen to Chinese speakers of English due to the lack of a clear boundary category between /Θ/ and /ε/ and because of the differences that exist between their L1 and L2. More interestingly, listeners repeated similar perception errors: /Y ~υ⌉, Θ ~∈, ε↔~∈⌉, AY ~ ↔Y/ with the native speakers which are likely to be raised by the same factors.

Moreover, the tense vs. lax patterns of perception errors such as /I⌉ ~I, Y ~ υ⌉/ are expected to be caused by the duration difference between English and Arabic. However, acoustically this claim seems to be less probable. This is because the long/short vowels of the Sudanese speakers' L1 (Arabic) show correspondence to English tense-lax vowels. Therefore, it is possible to classify such types of errors as by-products of the incorrect source of English vowels that probably resulted from the wrong realization or implementation of the English vowels. The wrong realization of English vowels can be attributed to interference of the Sudanese speakers' L1 (11, 21). In a related research, Bobda (2000) found that Sudanese speakers render English vowels /∈⌉/ to /∈ or ε/ and /εI/ to /ε/ due to effect of their L1 linguistic background. Actually, the incorrect production of the central and back English vowels presents frequent types of errors among Arabic speaking groups, which probably occurs due to the total absence of these types of vowels from Arabic vowel inventory (22). These findings indicate that Sudanese speakers of English have difficulty learning central and back English vowels.

Furthermore, in terms of acoustics, learning problems of English vowel pairs / {I, I⌉}, {Y ~υ⌉}, {Θ, ℘, ε}, {□⌉, □, A⌉}/ have been found to be the result of the closeness of such vowels in the vowel area. This means the closer the vowels within the vowel space are the more vulnerable they are to confusions. These confusions have been observed to take place only among EFL learners descend from language backgrounds with small number of vowels (23). This diagnosis seems to fit the Sudanese case whose L1 consists of a small number of vowels. It is also likely that the misperceptions of English vowels spoken by Sudanese speakers in this study is due to unfamiliarity of Dutch listeners with the Sudanese accented Arabic English since the lack of a close familiarity with the speakers' habits affects intelligibility process (24).

However, comparatively, the findings reveal an advantage for the native speakers of English strongly intelligible to Dutch listeners than to Sudanese speakers. Partly, because of the close relationship between English and Dutch



vowel inventory which correspond to some extent in terms of number and phonetic systems [20]. Moreover, Dutch listeners have sufficient exposure to English speech in every day life, which presents a kind of systematic practice of English. This factor enables the listeners to overcome many of the learning difficulties that might be experienced by non-native speakers of English lacking exposure to English.

6.2 Consonants

6.2.1 Consonant results

Figure.2 presents the correct identification of English consonants in a perception test done by ten Dutch listeners.

Figure.2 Correctly identified English consonants in a perception test done by ten Dutch listeners. The results are shown separately for consonants produced by the Sudanese accented-Arabic English and the native RP speaker.

Generally, listeners' performance in the consonants level is better than on vowels; total means of vowels in terms of Sudanese EFL learners and native speakers of English are 50% and 88 %, respectively. In consonants, the listeners' correct scores are 78% and 81% for consonants spoken by Sudanese and 100% and 99% for consonants spoken by native speakers of English, on onset and coda positions, respectively. In detail, Dutch listeners made more perception errors when they heard English consonants spoken by Sudanese speakers. On the onset level, frequent substitution errors were detected in consonant pairs /δ ~τ , Δ ~ζ, Τ ~σ, γ ~κ and ν ~ λ/. Fewer errors were also made in the perception of /δ, β, φ, ϖ, ω, τΣ, ν / where /δ / was misperceived as /π/, /β/ as /ϖ/ or φ/ interchangeably, /φ/ as /ϖ or ω/, /π/ was misperceived as /τΣ/ and /ν/ as /λ/. However, the listeners showed better perception on coda consonants. The most frequent error patterns on coda level are the substitution of the obstruent pairs /Δ~ζ, κ ~ γ, T ~ σ, τ ~ δ, σ ~ ζ, N ~ ν/. Although the rates of error are low, they are systematic and revealing: listeners often repeated the same types of perception errors on both onset and coda positions particularly with Sudanese speakers. On other the hand, figure.2 shows that Dutch listeners nearly had perfect perception of the English consonants spoken by native speakers, particularly on onset level. Only 10% of the perception errors were made where /Δ/ was replaced by /δ/. However, the listeners made more errors in coda consonants. The nasal /ν/ was misidentified as /N/ and /μ/, /Δ/ was replaced by /τ/, /κ/ by /γ/ and less frequently /ζ/ was replaced by /σ/. These results indicate that Dutch listeners found the native speakers of English more intelligible than Sudanese speakers.

Furthermore, tables.3, 4, 5 and 6 show a numerical account about the confusion matrices made in the perception of the English consonants. Tables 3 and 4 show the correct identification of the English consonants of ten Dutch listeners read by Sudanese speakers on both onset and coda positions. Tables 5 and 6 display the percentage of the same listeners in the same perception test but the items spoken by the native speakers of English. The correct identification appears in a diagonal line running across the table meanwhile the incorrect scores spread around. An interesting finding is that listeners made more perception errors on coda level with both consonant positions. The tables also show that in terms of speaker, Dutch listeners of English found the onset consonants spoken by the Sudanese group more difficult than coda consonants, and vice versa.

Table.3 Confusion matrix of English onset stimulus consonants spoken by Sudanese (in the rows) perceived by ten Dutch listeners (in the columns). Correct responses are on the main diagonal, indicated in bold face. Confusions areas appear around the diagonal line. (confusions =

Target	Responses																		
	β	δ	Δ	δZ	φ	γ	κ	λ	μ	ν	N	π	σ	τ	t	T	τΣ	ϖ	ζ
β	**9**						1												
δ		**10**																	
Δ			**5**																6
δZ				**10**															
φ					**10**														
γ						**8**													
κ						2	**3**					4			1				
λ				1				**9**											
μ	1								**9**										
ν										**10**									
N										1	**9**								
π							2					**8**							
σ													**10**						
Σ														**10**					
τ		3													**7**				
T													6			**3**			1
τΣ																	**10**		
ϖ																		**10**	
ζ													5						**5**

Table.4 Confusion matrix of English coda stimulus consonants spoken by Sudanese EFL learners (in the rows) perceived by ten Dutch listeners (in the columns). Correct responses are on the main diagonal, indicated in bold face. Confusions areas appear around the diagonal line. (confusions ≥ 3 are indicated in grey shaded cells).

Target	Responses																				
	□	□	Δ	δZ	□	γ	η	κ	λ	μ	ν	π	ρ	σ	Σ	τ	T	τΣ	ϖ	ω	ζ
□	**9**				1																
□		**0**										1				9					
Δ			**3**																		7
δZ				**10**																	
□	1				**9**																
γ						**5**		4				1									
η							**10**														
κ								**10**													
λ									**10**												
μ										**10**											
ν									4		**6**										
π												**8**						2			
ρ													**10**								
σ														**10**							
Σ															**10**						
τ																					
T														7			**3**				
τΣ																		**10**			
ϖ	2										1								**5**	2	
ω																				**10**	
ζ																					**10**

Table.5 Confusion matrix of English onset stimulus consonants spoken by native speakers of English (in the rows) perceived by ten Dutch listeners (in the columns). Correct responses are on the main diagonal, indicated in bold face. Confusions areas appear around the diagonal line. (confusions ≥ 3 are indicated in grey-shaded cells).

Target	Responses																	
	β	δ	Δ	δZ	ϕ	γ	η	κ	λ	μ	ν	π	ρ	σ	Σ	Τ	ϖ	ω	ζ
β	**10**																		
δ		**10**																	
Δ		1	**9**																
δZ				**10**															
ϕ					**10**														
γ						**10**													
η							**10**												
κ								**10**											
λ									**10**										
μ										**10**									
ν											**10**								
π												**10**							
ρ													**10**						
σ														**10**					
Σ															**10**				
Τ																**10**			
ϖ																	**10**		
ω																		**10**	
ζ																			**10**

Table.6 Confusion matrix of English coda stimulus consonants spoken by native speakers of English (in the rows) perceived by ten Dutch listeners (in the columns). Correct responses are on the main diagonal, indicated in bold face. Confusions areas appear around the diagonal line. (confusions ≥ 3 are indicated in grey-shaded cells).

Target	Responses																		
	β	δ	Δ	δZ	φ	γ	κ	λ	μ	ν	N	π	σ	Σ	τ	T	τΣ	ϖ	ζ
β	**10**																		
δ		**10**																	
Δ			**8**												2				
δZ				**9**														1	
φ					**10**														
γ						**10**													
κ						1	**9**												
λ				1				**9**											
μ									**9**	1									
ν									3	**7**									
N											**10**								
π		1										**9**							
σ													**10**						
Σ														**10**					
τ															**10**				
T																**8**		2	
τΣ																	**10**		
ϖ																		**10**	
ζ													1						**9**

6.2.2 Discussion and conclusions

The replacement errors /τ~δ, κ~γ, φ~ϖ, ν~λ, ζ~σ/ indicate similarity in the place of articulation between such tokens, however, they might be caused by the unfamiliarity of Dutch listeners with Sudanese English. It is also possible to refer these types of English consonant perception errors to different voicing contrasts utilized in their production- Arabic consonant inventory; i.e. absence of energy required for English voiceless consonants. The latter reasoning applies particularly to the misperceptions of the English /τ/ as /δ/, /Δ/ as /ζ/ and /T/ as /σ/ where the speakers' L1 (Arabic) transfer acts as a barrier that blocks the acquisition of the L2 consonants and passes only Arabic speech sounds- L1 filter effect. Previous studies revealed that many Arabic speakers of English have difficulty producing /T, Δ, σ, ζ/ due to L1 interference [25, 26, 27]. A good example of L1 interference, has been observed in a recent research which revealed that the boundaries between fricative and dental fricative pairs /τ~δ, Δ~ζ, T~σ/, in Sudanese colloquial Arabic, have almost become blurred [28].This is most probably the reason that why Dutch listeners substitute these fricatives. Interestingly, this conclusion accounts for the repetition of the same error patterns made by Dutch listeners on the onset and coda consonants that were produced by the Sudanese speakers. More interestingly, such error patterns were not witnessed to occur with the English consonants produced by the native speakers of English at all.

The misperception of /φ/ as /ω/ can be referred to as an orthographic issue where Dutch /ω/is treated as /ϖ/ probably because of the absence of energy contrast – not consistent or totally absent – in Dutch φ/ϖ. Phonologically, the interchangeable substitutions of /φ/ for /ϖ/ are seen as L1 filter of the Dutch listeners' perceptual and productive inventory. This is because the contrast between these bilabials is not a matter of fortis/ lenis (voiced ~ voiceless) [6]. The misidentification of English /ν/ as /μ/ which were pronounced by native speakers of English in word-final position can be attributed to the claim that the vocalic nature of nasals is underlined by the fact that they perform the syllabic function of vowels. Thus, RP nasal /ν/ was counted as /N/ or /μ/. This phenomenon occurs when words like *mutton* are heard as /μ℘τN/ or /μ℘τμ/ and *bacon* as /βεIκN/ or /βεIκμ/ [23]. Linguistically, English and Dutch languages show contrasts in phonological representations of the same phonemes, which motivate the assumption that Dutch listeners perceive English nasals with their L1 categories. The misidentification of RP /Δ/ as /δ, or τ/ is due to inter-language effect (using a language system which is neither the L1, nor the L2). This is because as the Dutch consonant system (ABN) suggests that /Δ/ has the status of a plosive in the listeners' inter-language [29]. In conclusion, the performance of the Dutch listeners in consonants is better than vowels with both Sudanese and native speakers of English. This suggests that English consonants are more intelligible to Dutch listeners than vowels.

6.3 Consonant clusters

6.3.1 Results.

Figures.3 and .4 present the correctly identified English cluster consonants spoken by Sudanese and native speakers of English in a perception test done by ten Dutch listeners.

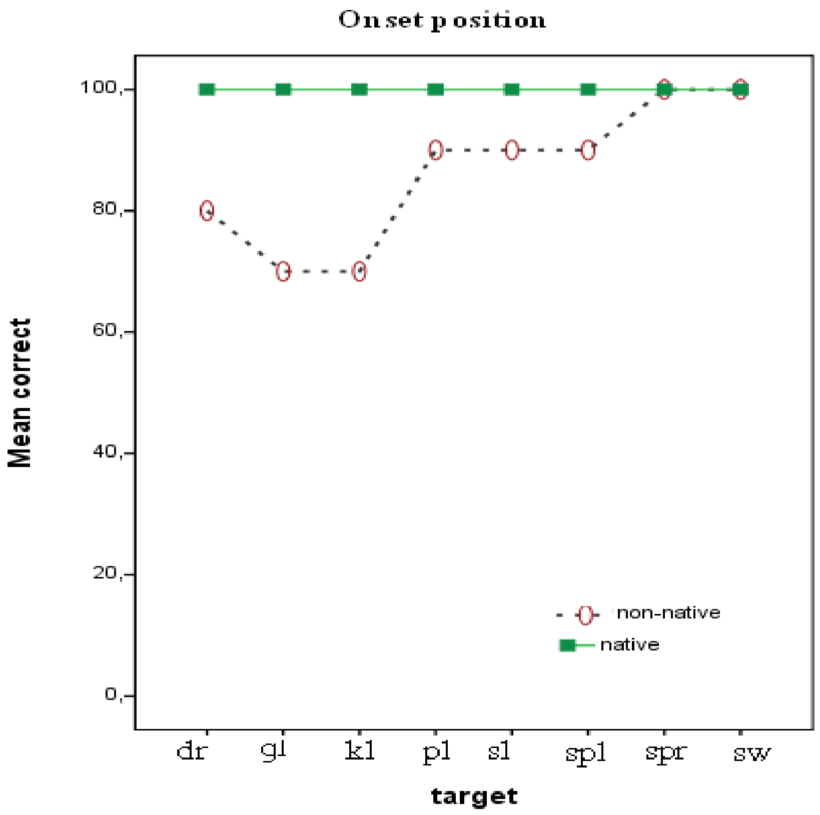


Figure.3 Correctly identified English onset consonant clusters of ten Dutch listeners spoken by Sudanese and native speakers of English.

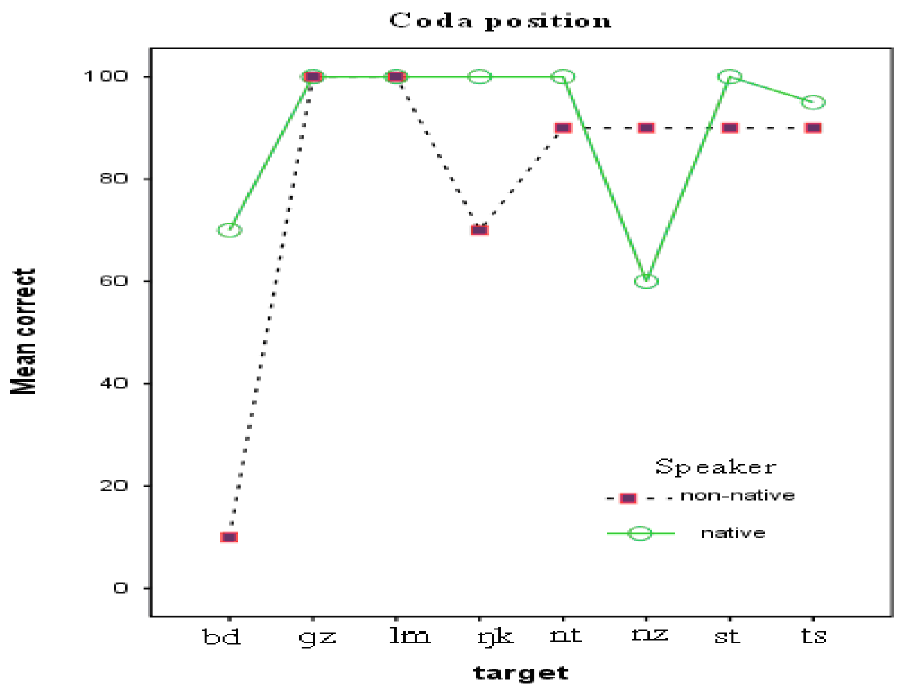


Figure.4 Correctly identified English coda consonant clusters of ten Dutch listeners spoken by Sudanese and native speakers of English

As the results in figures .3 and .4 show Dutch listeners had better performance on English cluster consonants than on vowels and single consonants levels. Their performance was even better when they were exposed to the native speakers of English than to the Sudanese speakers. The total means; vowels are 50% and 88%, onset and coda consonants 78% and 81% against 99 % and 99% and onset and coda cluster consonants are 86% and 81% against 100% and 91% for Sudanese and native speakers of English, respectively. On the onset level, the cluster items spoken by the native speakers were perfectly identified by the listeners except a slight error rate of 10% made in the perception of /σπρ/. However, more substitution errors /δρ/ for /βρ and γρ/, /γλ/, for /κλ/, /πλ/, for /φλ/, /σλ/ for /σν/ and /σπλ/ for /σκω/ were made by the listeners when they heard the same onset items spoken by Sudanese subjects. These findings indicate that the onset consonant clusters read by the native speakers of English are more understandable to Dutch listeners than those of the Sudanese speakers are. They also show that the misperception of the cluster pairs /κλ ~γλ, σλ~σν, πλ ~φλ/ is revealing and more systematic than /δρ~βρ or γρ/ from one hand, and /σπλ ~σκω/ from other.

Additionally, tables.7, .8, .9 and .10 present the confusion matrices of the listeners correct identification as well as the problematic areas of the cluster consonants at both onset and coda positions. Tables.7 and .8 show the correct identification of English cluster consonants of ten Dutch listeners spoken by

Sudanese speakers on both onset and coda positions, whilst tables .9 and .10 display the percentage of the same listeners in the same perception tests but spoken by native speakers of English. The correct identification appears in a diagonal line running across each table meanwhile the errors scatter around such a line. In tables .7 and .9 there are relatively fewer errors made in the perception of the onset clusters spoken by both Sudanese and native speakers of English; replacement of /σπρ ~ σπλ/. However, a few more errors were made by Dutch listeners in the identification of English clusters produced by the Sudanese speakers as table.7 shows. These are the misperception of /σπλ/ as /σκω/.

On the other hand, tables.8 and, .10 show that Dutch listeners made more perception errors in the perception of the coda clusters produced by Sudanese EFL learners and native speakers of English. The data also showed patterns of identical perception errors on the coda level with both speakers. The listeners substituted /νζ/ for /μζ/ and less frequently /βδ/ for /ιτ/ (/ιτ/ is not a cluster member) /or /λδ /.The listeners were also observed to mistake /νκ/ for /νδ/, /στ/ for /σκ/, /ντ/ for /μπ/ and /νζ/ for /τσ/ or /δZ/. However, the error ratios of Dutch listeners in the cluster items spoken by Sudanese EFL learners are higher, particularly coda clusters. These findings reveal that there is a positive relation between the listeners' performance in single and cluster consonants than between the clusters and vowels (see: correlation).

Table .7 Confusion matrix of English onset stimulus consonant clusters spoken by Sudanese speakers of English (in the rows) perceived by ten Dutch listeners (in the columns). Correct responses are on the main diagonal, indicated in bold face. Confusions areas appear around the diagonal line. (confusions = / > 3 are indicated in grey shaded cells).

	Responses													
Target	δρ	γλ	κλ	πλ	σλ	σπλ	σπρ	σω	βλ	βρ	φλ	γρ	σκω	σν
δρ	**8**									1		1		
γλ		**7**							3					
κλ		3	**7**											
πλ				**9**							1			
σλ					**9**									1
σπλ						**9**							1	
σπρ							**10**							
σω								**10**						

Table.8 Confusion matrix of English coda stimulus consonant clusters spoken by Sudanese speakers of English (in the rows) perceived by ten Dutch listeners (in the columns). Correct responses are on the main diagonal, indicated in bold face. Confusions areas appear around the diagonal line. (confusions = / > 3 are indicated in grey shaded cells).

	Responses														
Target	βδ	γζ	λμ	″κ	ντ	νζ	στ	τσ	λδ	δT	ιτ	μπ	μζ	νδ	σκ
βδ	**1**		6						2		1				
γζ		**10**													
λμ			**10**												
″κ				**7**										3	
ντ					**9**							1			
νζ						**8**		1					1		
στ							**7**								3
τσ								**8**		2					

Table.9 Confusion matrix of English onset stimulus consonant clusters spoken by native speakers of English (in the rows) perceived by ten Dutch listeners (in

the columns). Correct responses are on the main diagonal, indicated in bold face. Confusions areas appear around the diagonal line. (confusions = / > 3 are indicated in grey shaded cells).

Target	Responses							
	δρ	γλ	κλ	πλ	σλ	σπλ	σπρ	σω
δρ	**10**							
γλ		**10**						
κλ			**10**					
πλ				**10**				
σλ					**10**			
σπλ						**10**		
σπρ						1	**9**	
σω								**10**

Table.10 Confusion matrix of English coda stimulus consonant clusters spoken by native speakers of English (in the rows) perceived by ten Dutch listeners (in the columns). Correct responses are on the main diagonal, indicated in bold face. Confusions areas appear around the diagonal line. (confusions ≥ 3 are indicated in grey shaded cells).

Target	Responses											
	βδ	γζ	λμ	″κ	ντ	νζ	στ	τσ	φσ	ιτ	μζ	λδ
βδ	**6**									1		3
γζ		**10**										
λμ			**10**									
″κ				**10**								
ντ					**10**							
νζ						**6**					4	
στ							**10**					
τσ								**9**	1			

6.3.2 Discussion

Errors made by Dutch listeners in the perception of the velar /κλ~ γλ/ and alveolar /σλ ~ σν/ initial cluster members spoken by Sudanese subjects, probably occur due to imprecise or absence of energy required for voiceless sounds [23]. Moreover, the error pattern /δρ~ βρ/ and /σπρ~ σπλ/ can be attributed to the similarity in the manner of articulation, or to voicing, whilst

/πλ~ϕλ/ misperception can be seen due to labiality shared by the first cluster members. Additionally, the listeners' errors of the initial member of coda clusters /νζ ~ μζ/ are most likely caused by nasality. Dutch listeners were observed to repeat similar types of errors with both Sudanese and native speakers, which indicate that these error patterns have to do with Dutch listeners. Despite the fact that each of English and Dutch languages has distinctive phonological representations, they show a kind of linguistic correspondence to each other. The listeners showed better performance of English clusters produced by native speakers than with Sudanese speakers. [20] reported similar conclusions that Dutch listeners had better performance in the English clusters produced by Americans due to the sufficient linguistic similarity that exists between Dutch listeners L1 and L2.

6.4 Results and discussion of Speech in noise-test (SPIN)

Figure.5 presents the scores of ten Dutch listeners obtained in the SPIN test, which were read by both Sudanese and native speakers of English.

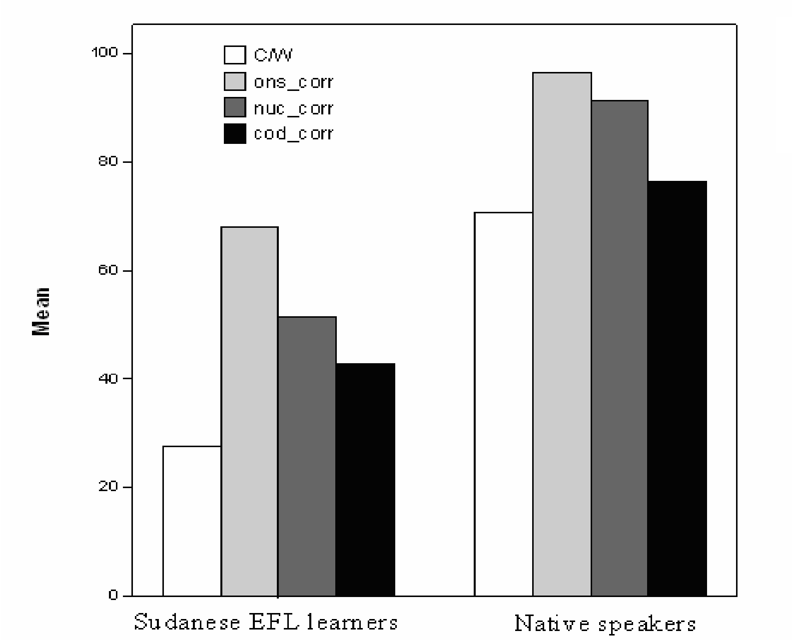


Figure .5 Mean percentages of the scores of ten Dutch listeners obtained in SPIN test which were read by both Sudanese EFL learners and native speakers of English.

As figure .5 shows, Dutch listeners had a poor perception in simple and predictable English sentences that reached 27% when such sentences were spoken by Sudanese speakers. However, the listeners had a better performance of 70% in the same test read by the native speakers. Similarly, they had lower scores on onset, nucleus and coda positions in the SPIN items read by Sudanese speakers; 68%, 51% and 42% against higher scores 96%, 91% and 76% when the same SPIN items were read by the native speakers. These results indicate that the SPIN sentences of the native speakers are more intelligible to Dutch listeners than the sentences of the Sudanese speakers. The results also reveal that Dutch listeners of English managed to recognize some sounds in the words correctly. The onsets were perceived more accurately than the vowels and the codas tie with the results of the MRT tests.

Moreover, the findings indicate that onsets consonants, whether single or clustered were identified more successfully than vowels and codas. This implies that the listeners' performance is always better when they hear native speakers.

6.5 Correlations

Tables4.11 and .12 present the correlations between the four parts of this study. These parts include vowels, single and cluster consonants and words as whole units of English. The tables show how English vowels and consonants correlate with each other and with the sentences from other hand. They also present the relation between vowels, single, cluster consonants, and their counterparts on word level.

Table.11 Correlation matrix of dependent variables (identification scores) for materials produced by nonnative speaker.

	Vowels	Consonants	cons._ons	cons_cod	clusters	clust_ons	clust_cod	word_all	word_ons	word_nuc
consonants	.154									
cons_ons	.336	**.944**								
cons_cod	–.329	**.688**								
Clusters	-.489	–.329	–.498	.188						
clust_ons	–**.630**	–.385	–.551	.153	.951					
clust_cod	–.266	–.224	–.375	.205	**.933**	.777				
word_all	.359	–.060	–.006	–.179	–.297	–.270	–.292			
word_ons	.818	.309	.485	–.232	–**.623**	–**.699**	–.456	**.569**		
word_nuc	.461	.217	.269	–.014	–.144	–.322	.080	**.659**	**.604**	
word_cod	.138	–.274	–.274	–.165	.239	.315	.122	.285	.263	–.137

Bolded r > .8: p ≤ 0.01 (2-tailed).
Bolded r < .7: p ≤ 0.05 (2-tailed).

Table.12 Correlation matrix of dependent variables (identification scores) for materials produced by native speaker.

	vowels	Consonants	cons._ons	cons_cod	clusters	clust_ons	clust_cod	word_all	word_ons	word_nuc
consonants	–.186									
cons_ons	.171	–.021								
cons_cod	–.211	**.982**	–.207							
Clusters	.278	–.078	–.444	.000						
clust_ons	a	a	a	a	a					
clust_cod	.278	–.078	–.444	.000	1.000	a				
word_all	–.454	–.186	–.032	–.176	–.284	a	–.284			
word_ons	–.046	.003	.035	.000	–.035	a	–.035	.379		
word_nuc	–.420	–.175	–.212	–.131	–.230	a	–.230	**.945**	.292	
word_cod	–.446	–.215	.014	–.216	–.087	a	–.087	**.939**	.410	.811

a No *r* can be computed because at least one of the variables is constant. (perfect scores only)
Bolded *r* > .8: p ≤ 0.01 (2-tailed).

The computation of the correlation coefficient of vowels, single and cluster consonants and SPIN sentences provides statistical support. A positive relationship exists between nucleus and words correct identification (*r*-value is .659 (sig.01) and 945. (sig.05) produced by both Sudanese and native speakers, respectively. This relation reveals that listeners usually get a correct word score whenever a nucleus vowel is correctly recognized, which in turn indicates that the perception of vowels is a decisive factor of word predictability. This diagnosis implies a kind of practical sense, which supports the literature suggesting that although vowel sounds do not bear meaning like consonants, they work as important cues to help figure out word identities. Moreover, there is a negative relationship between the coda consonants and word codas spoken by both Sudanese and native speakers: r = –.165 and –.216, respectively. This relation indicates that when Dutch listeners make perception errors on consonant codas they also make perception errors on word codas with both speakers. It suggests single and cluster coda consonants are more difficult to perceive than their onset counterparts. A weak but positive correlation exists between vowels and onset consonants: r =.336 and .171 for Sudanese and native speakers of English, respectively. It raises the prediction that the correct identification of English vowels assumes correct identification of English onset consonants. However, these weak positive or negative relations imply a sort of unstable performance reflected by Dutch listeners when they are exposed to Sudanese speakers. It can be interpreted as a by-product of incorrect pronunciation of the source items of Sudanese speakers. That is, incorrect pronunciation of some CVC stimuli changes their meaning, which influences their predictability. Data of a similar test [20] supports the claim that correct identification of Dutch listeners with Chinese speakers is poorer (32%) than with the native speakers (67%). Dutch listeners had a high word correct percentage due to more exposure to English than the former two groups. Moreover, linguistically their L1 norm is much closer to English than Sudanese and Chinese listeners. Chinese and Sudanese listeners speak English as a second/foreign language, their L1 linguistic systems are entirely unrelated to English, the former being a Sino-Tibetan and the latter a Semitic language. Previous studies which measured the perceptual similarity between languages on the basis of their overall sound structure, found that the mean distance of Dutch from English is (3.7) and that the proximity of Dutch to English is based on known genetic and structural similarities. According to such study Arabic is (12.5), which labels it as the farthest language from English and Dutch compared to other languages [30]. In conclusion, the findings reveal that the perception of vowels and coda consonants are more difficult for Dutch listeners than single and cluster consonants.

6.6 General conclusions

Dutch listeners made more perception errors on English central and back vowels read by Sudanese speakers than with those of the native speakers probably due to incorrect English source vowels. These type of vowels are absent from the Sudanese speakers' L1 (Arabic) vowel inventory.

Similar perception errors were experienced in perceiving English onset and coda consonants produced by Sudanese speakers. The English fricative obstruents /Δ, ζ, T, σ/ proved to be problematic for Dutch listeners. These types of perception errors can be interpreted as a by-product of incorrect English source.

Generally, fewer errors were made on consonant clusters level. Moreover, the listeners made even less perception errors of English single and clustered consonants when the material was read by native speakers of English.

Dutch listeners found the native speakers of English more intelligible than Sudanese speakers because English and Dutch languages share similar linguistic backgrounds. Secondly, Dutch listeners have regular exposure to target language, which facilitates learning of English. Thirdly, they are not familiar with Sudanese accented English.

Sudanese-Arabic speakers attain more difficulties in producing English vowels than single and clustered consonants because they are not familiar with a large number of vowels.

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