TESTING THE PERCEPTUAL CONTRAST BETWEEN /o/ AND /ɔ/, AND /e/ AND /ɛ/ IN KINSHASA LINGALA

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1. Introduction

1.1 Motivation

This research tests the claim that the perceptual contrast between the vowels /ɔ/ and /o/, and /ɛ/ and /e/ have been neutralized in Kinshasa Lingala (KL). Previous studies have claimed that the vowels /ɔ/ and /ɛ/ have merged into /o/ and /e/ respectively (Campbell and King 2013, Montingea 2006, Bokamba 2012). This assumed merger has resulted in the claim that KL has 5 vowels as opposed to Makanza Lingala (ML), which has 7. However, this claim has never been tested empirically, that is, no study has ever empirically demonstrated the merger of those vowels through robust findings. Also, it has never been specified whether this merger is perceptual or articulatory.

Most studies, which have formulated the aforementioned claim on the vowel system in KL were conducted without any support of the new technology in linguistics. None of those studies have used any phonetic software to analyze those sounds in order to back their claims. In most of those studies, researchers relied upon their intuition as native speakers of KL and upon their auditory skills to discriminate between the pairs of vowels /ɔ/ and /o/, and /ɛ/ and /e/, and on the basis of their intuition as native speakers of Lingala, they concluded that vowels /ɔ/ and /ɛ/ have been merged to /o/ and /e/ respectively. I believe that reliance on only the native auditory skills is not enough to back up one's claim. An analysis of the acoustic characteristics of those targeted vowel sounds would help to provide an effective answer to the concern of this research.

In this study, however, I aim to test the perceptual abilities of KL speakers on the contrast between the pairs of vowels /ɔ/ and /o/, and /ɛ/ and /e/. I administered a picture-auditory contrastive task to the subjects to test their ability to discriminate between those pairs of vowel sounds. This test will determine whether KL speakers perceptually discriminate between the pairs of aforementioned vowels. I further use the Signal Detection Theory (SDT) to determine their sensitivity in discriminating between those pairs of vowels.

1.2 Research questions and predictions

The question of this research seeks to determine whether there is effectively loss of perceptual contrast between the pairs of vowels /ɔ/ and /o/, and /ɛ/ and /e/. The hypotheses of the study predict that if there is effective perceptual neutralization between /ɔ/ and /o/, and /ɛ/ and /e/, when a linguistic item containing the vowel /ɔ/ is played, the participants

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will select the element of the minimal pair with the targeted vowel /o/ as the targeted linguistic item that they have perceived. Likewise, when a linguistic item containing the vowel /ɛ/ is played, the participants will select the element of the minimal pair with the targeted vowel /e/ as the targeted linguistic item that they have perceived. Such selections have provided evidence of the loss of the perceptual contrast between the targeted pairs of vowels in KL.

2. Background: Neutralization and incomplete neutralization

Neutralization is a phonological process which consists in the loss of the contrastive or distinctive features between two sounds in a certain environment. Two segments which contrast in one environment are said to be neutralized when they have the same representation in a particular environment. In many languages of the world, such as Russian, Turkish, Dutch, Catalan, Polish, and German to name but a few, voiced obstruents which contrast intervocalically have the contrast neutralized in syllable or word final position in favor of voiceless obstruents (Roettger et al. 2014: 2). In German, for instance, the contrast between /t/ and /d/ as in [bunte] and [bunde], '*Räder* [ʁæːdɐ] 'wheels' and *Räte* [ʁæːtə] 'councils' is attested. However, this contrast is claimed to be neutralized in syllable final position as in Rad [ʁaːt] 'wheel' vs. Rat [ʁaːt] 'council'; Radschlag [ʁaːtʃlaːk] 'cartwheel' vs. Ratschlag [ʁaːtʃlaːk] 'advice'; and in bund [bunt] 'brotherhood' vs. bunt [bunt] 'colorful'. These cases of consonant neutralization in German in which the voicing feature of alveolar stops is neutralized in syllable final position results in apparent homophony between the pairs of lexical items.

Roettger et al. (2014: 2) postulate "In traditional formal theories of phonology, Rad and Rat are thought to differ only in their underlying "lexical" representations, while the surface form of the voiced stop is thought to be phonetically indistinguishable from that of the corresponding voiceless stop". In fact, the aforementioned studies had attested that neutralization of the final voicing obstruent in German is phonetically complete.

However, some experiment in the studies of scholars such as Mitleb (1981), Port and O'Dell (1986), and Port and Crawford (1989) have shown in either a production or perception study with minimal pairs that the two sets of [t]-like sounds are consistently different. Production data have revealed statistically significant differences between the two sets [t]-like. The [bunt] that is realized from the underlying /t/ has a shorter preceding vowel and slightly longer closure than the [bunt] related to lexical /d/ (Port 1996, 1997).

The slight contrastive differences between these pairs of segments in word-final position is attributed to the "underlying voicing feature which is still biasing the phonetic detail of the stops despite the fact that most of the differences between the voicing classes have been wiped away when the stop or fricative occurs in this syllabic position" (Port 1997). Needles to recall that vowels are longer before devoiced stops than before final voiceless stops. As a matter of fact, Port and Crawford (1989) found a difference of 1.2-6.2 ms between the devoiced and voiceless stops in German, Port et al. (1985) found the difference of 15 ms; however, Warner et al. (2004) found a difference of 3.5 ms in Dutch. These differences in the duration of vowels that precede the devoiced stop as opposed to the voiceless stop are evidence of incomplete neutralization.

If the two segments were completely neutralized, we would expect no differences in terms of the duration of those vowels. However, I wonder whether those vowel duration differences are statistically significant. If not, this could raise doubt in terms of the rigor of the methodology that was used in those studies and the interpretation that was assigned to the results of those studies. Anyway, these cases of partial neutralization of the voicing distinction in domain final position are deemed phonetically incomplete.

Fox and Terbeek (1977) showed in their study that the contrast between /t/ and /d/ in the pair of words 'budding' vs. 'butting' is just partially neutralized. They found that the vowel preceding the flaps tends to be different in terms of timing. That is, a vowel that precedes a flap that is realized from an underlying /t/ is shorter than a vowel that precedes a flap that is realized from an underlying /d/. This tendency was also attested in Port (1996), Huff (1980), and Chin (1986).

The claim on incomplete neutralization in German has been subject to criticism on methodological grounds. Since German presents orthographic contrast between voiced/devoiced and voiceless stops, and most of the aforementioned studies have administered a list of words that participants had to read aloud, criticism on incomplete neutralization argued that participants used hypercorrection or spelling pronunciation (Roettger et al. 2014). Roettger et al (2014: 3) reporting those criticisms said, "as laboratory settings tend to elicit more formal and clear speech, participants might have produced words based on the written language in a way that they would not do in everyday speech". Such studies by Fourakis el al. (1984) and Jassem and Lutoslawa (1989) have frequently been mentioned as evidence against incomplete neutralization.

In fact, in Fourakis and Iverson (1984) four participants were asked to conjugate neutralized verb forms such as '*mied*' 'avoid', which was auditorily presented with non-neutralized forms such as '*meiden*' 'to avoid' in the experiment. The results showed no statistical significant incomplete neutralization effect (Roettger et al. 2014: 3). Likewise, Jassem and Lutoslawa (1989) conducted a similar study in Polish in which four participants were asked to answer some structured questions which aimed to elicit a single word containing the target token as answer. They measured the duration of the target preceding vowel, voicing-into-the closure/frication, closure/frication duration, and release duration. The results showed no incomplete neutralization effect. These null results were interpreted as evidence for the absence of incomplete neutralization (Roettger et al. 2014: 3). The two studies were criticized for their limited number of participants (four subjects for each study) and their null results were attributed to lack of statistical power (Roettger et al. 2014).

However, studies that investigated the perception in incomplete neutralization were criticized on the methodological grounds as well. They were accused of using a small set of speakers, or just a single speaker which "gives participants ample opportunity to familiarize themselves with speaker characteristics" (Roettger et al. 2014: 3) and this has made the task easier for the participants "to detect subtle cues to voicing in a neutralizing context, enhancing the likelihood that they might be attending to cues that they would not use in listening situations outside of the laboratory" (Roettger et al. 2014: 3).

It is true that a number of methodological shortcomings have been identified in previous studies on incomplete neutralization. Those which have failed to find incomplete neutralization effect have as well been subject to methodological criticism. They have been warned not to consider "failure to find an effect as evidence for the absence of that effect" (Roettger et al. 2014: 3).

Roettger et al. (2014) decided to address the methodological criticisms in a study in which three production experiments and one perception experiment were conducted. They addressed the role of orthography in the production study, and used pseudo-words in an auditory task. They found robust incomplete neutralization effects in production, while in perception study the effects were weak. They found in the perception study that the sub-phonemic differences between final voiceless and 'devoiced stops' are audible, but only barely so. Kleber et al. (2010) for instance, found that the perceptual differences between the devoiced stops and the voiceless stops could be identified with above-chance accuracy (Roettger et al. 2014). Roettger et al. attributed the previous null results to lack of statistical power.

If German incomplete neutralization is somewhat a potential result of an orthographically induced contrast, as Roettger et al. circumscribe it as a concern to address in their study, this is however not a concern in this study. Orthography in KL does not present any contrast with vowels. Mid-vowel contrast in KL is purely phonemic. Therefore, orthographic parameter does not play any role in this study, and it does not need to be controlled. However, for the sake of efficient methodology, which could lead to reliable results, any reading aloud technique has been discarded in this study, because, as documented in the literature, "speakers activate orthographic representations even in completely auditory tasks" (Dehaene et al. 2010, Perre et al. 2009, Seidenberg and Tanenhaus 1979, Ziegler and Ferrand 1998). Instead, I have used picture-audio contrastive task and picture elicitation task to collect the data of this study.

Roettger et al. (2014: 11) found that vowel duration was a robust acoustic correlate of devoiced and voiceless stops in syllable-final position to account for incomplete neutralization. Roettger et al. (2014) ascertained that, "Vowels were longer before devoiced stops than before voiceless stops." They came to the firm conclusion that there is incomplete neutralization in both perception and production studies with regards to the contrast between /t/ and /d/ in syllable final domain. These findings agree with the large body of evidence in favor of incomplete neutralization as opposed to complete neutralization.

Furthermore, a number of experimental studies have shown that there are slight acoustic and articulatory differences between the [t] in '*Rad'* and '*Rat'*. Such studies as of Charles-Luce (1985), Dinnsen (1985), Dinnsen and Garcia-Zamor (1971), Fuchs (2005), Greisbach (2001), Mitleb (1981), O'Dell and Port (1983), Port and O'Dell (1985), Piroth and Janker (2004), have found that /t/ and /d/ in syllable final position in German is a case of incomplete neutralization. Incomplete neutralization is accounted for with reference to lexical representations. Ernestus and Baayen (2006) for instance argue that incomplete neutralization effects may be attributed to the co-activation of paradigmatically related forms. Roettger et al. (2014: 12) basing their account of incomplete neutralization on the concept of spreading activation (Collins et al. 1975), clarify this point by arguing that "when speakers pronounce Rad, they also activate the non-neutralized Rader. This co-articulation of the related voiced forms could influence the speech production mechanism in subtle ways, leading to incomplete neutralization."

The debate surrounding incomplete neutralization is still ongoing. Studies on incomplete neutralization in other languages are legion. Warner et al. (2004) examined incomplete neutralization of final devoicing in Dutch, Charles-Luce and Dinnsen (1987) in Catalan, Slowiaczek and Dinnsen (1985) in Polish, and Dmitrieva et al. (2010) and Kharlamov (2012) in Russian. Roettger et al. (2014: 2), quoting Fuchs (2005: 25) argue that, "the debate surrounding incomplete neutralization has become increasingly a debate about methodology rather than the phenomenon per se." I completely agree that an inappropriate methodology could impact the study and bias the results. An appropriate methodology for data elicitation is relevant for sound and robust findings.

3. Methodology

3.1 The participants

Fifty-six participants were used for this study. There were twenty-seven females and twenty-nine males. All the subjects were native speakers of Kinshasa-Lingala who were born and grew up in Kinshasa. They all speak KL as their first language (L1) and use it on a daily basis as a language of communication at home, the workplace for those who work, and for other daily social interactions such as in buying or selling, and bargaining, to name just a few instances, and are also fluent in French.

The subjects were further divided into two main groups in terms of their gender and age. Considering age as a variable, the subjects were recruited on the basis of whether they were younger or older than thirty-five years old. There were in total twenty-nine males of which thirteen were under thirty-five years old and sixteen were older than thirty-five years old. Twenty-seven were females of which fourteen were younger than thirty-five while thirteen were older than thirty-five years old.

3.2 Task and procedures

A picture-audio contrastive task was administered to the participants. The task was made up of fourteen pairs of pictures which represented a minimal pair which contrasted on either /ɔ/ and /o/, or on /ɛ/ and /e/. The pair of contrastive pictures were presented on the screen of a computer and the audio file which corresponded to one of the pictures was played. The participant role was to pick the picture which corresponded to the word that was pronounced in the audio file. For instance, a pair of pictures [^{m}bɔ^{ŋ}gɔ] 'fish' vs. [^{m}bo^{ŋ}go] 'money' was displayed on a power point with an audio on the screen of a computer. The two pairs of pictures contrasted in the quality of the vowels /ɔ/ vs. /o/. Participants had to pick the picture which was associated with the word that was pronounced.

An answer sheet was provided so that participants could write down their answers. The answer sheet was presented in three columns of which the first was the ordinal number of the pairs of pictures; the second column was made up of letter 'a' and the third with letter 'b'. Letter 'a' represented the picture on the left hand side for each pair in the power point slide on the screen and letter 'b' represented the picture on the right hand side for each pair in the power point slide on the computer screen.

The instructions were given in Kinshasa Lingala. The procedures were explained to the participants prior to the task being administered. Participants had time to ask any clarification questions on the procedures. An illustration was provided in order to make things clearer for the participants. The instruction required participants to circle the letter that represents the association between the picture on the power point slide and the word that has been pronounced. Prior to starting with the task proper, participants had to provide their age range, either younger or older than thirty-five years old and specify whether they were male or female.

3.3 Data analysis

The frequency of the participants' answers was computed to determine their trends in their perceptual ability to discriminate between the pairs of vowels /ɔ/ and /o/, and /ɛ/ and /e/. A t-test was run to determine whether the frequency differences in their perceptual ability to discriminate between those targeted vowels were significant.

Furthermore, the Signal Detection Theory (SDT) was used to determine the computed values of the d-prime in order to reveal the level of contrastive sensitivity between the two pairs of vowels, and to determine the level of bias in their decision on the word that has been heard in the task. The SDT helps to analyze the decision making in case of the presence of uncertainty in any sensory experiment (Heeger 1998). In a perception task, there are four possible situations that need to be discussed here. (1) When there is the signal, and the participant responds by 'yes' that s/he heard the signal this is a HIT. (2) When the signal is present and the participant says s/he did not hear the signal is a MISS. (3) When the signal is absent and the participant says s/he heard the signal that is FALSE ALARM. (4) When there is no signal and the participant says s/he did not hear the signal this is CORRECT REJECTION. These four situations are presented in table 1.

Table 1: Four possible situations in SDT

	Response: YES	Response: NO
Signal: Present	HIT	MISS
Signal: Absent	FALSE ALARM	CORRECT REJECTION

I am interested in the values of HIT and FALSE ALARM in order to determine the subjects' sensitivity to discriminate the differences between the pairs of vowels /ɔ/ and /o/, and /ɛ/ and /e/. D-prime is the difference between the z-transforms of HITS and FALSE ALARMS that determines the distance between the signal and the Signal + Noise (Macmillan and Creelman 1991). d'= z(Hit) – z (False alarm)

3.4 The results

The computing of the frequency differences between the right and wrong answers on the perceptual discriminations of the targeted vowels have been computed. The results are presented in terms of frequency and in percent in the following tables. Therefore, the figures in the tables represent the frequencies of the answers provided by the participants.

3.4.1 Perceptual contrast results between /ɔ/ and /o/

Table 2: General results of the perceptual contrast between /ɔ/ and /o/

Vowels	RIGHT		WRONG	
	Frequency	%	Frequency	%
/ɔ/	141	62.9	83	37
/o/	246	87.8	34	12

Table 3: Female vs male results of the perceptual contrast between /ɔ/ and /o/

Vowels	Female				Male			
	RIGHT		WRONG		RIGHT		WRONG	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
/ɔ/	68	48.2	38	45.7	73	51.7	41	49.3
/o/	113	45.9	17	50	133	54	17	50

Table 4: Age differences results of the perceptual contrast between /ɔ/ and /o/

Vowels	+35 old				-35 old			
	RIGHT		WRONG		RIGHT		WRONG	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
/ɔ/	74	52.4	42	50.6	67	47.5	41	49.3
/o/	129	52.4	17	50	117	47.5	17	50

3.4.2 Perceptual contrast results between /ɛ/ and /e/

Table 5: General results of the perceptual contrast between /ɛ/ and /e/

Vowels	RIGHT		WRONG	
	Frequency	%	Frequency	%
/ɛ/	106	63	62	36.9
/e/	86	76.1	27	23.8

Table 6: Female vs male results of the perceptual contrast between /ɛ/ and /e/

Vowels	Female				Male			
	RIGHT		WRONG		RIGHT		WRONG	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
/ɛ/	48	45.2	29	46.7	58	54.7	33	53.2
/e/	37	43	16	59.2	49	56.9	11	40.7

Table 7: Age differences results of the perceptual contrast between /ɛ/ and /e/

Vowels	+35 old				-35 old			
	RIGHT		WRONG		RIGHT		WRONG	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
/ɛ/	52	49	35	56.4	54	50.9	27	43.5
/e/	43	50	15	55.5	43	50	12	44.4

3.4.3 The results of the Signal Detection Theory

This section computes the values of both d-prime and bias. The values of each individual's d-prime are computed in order to be able to further compute the significance of the differences between the HIT (H) and the FALSE ALARM (FA). The following section presents the results of the sensitivity and bias for the group as a whole.

In this experiment, there were two types of detection trials of which the first had the signal and the other one contained no signal. The detection sensitivity was computed using the hit rates and the false alarm rates as they were recorded in the tables below. In the following, I compute the measured sensory capacity of my subjects. Table (8) presents the data of the perceptual contrast between the pair of vowels /ɔ/ and /o/ in which case the former, that is, /ɔ/ indicates the presence of the signal, while /o/ indicates the absence of the signal.

Table 8: The perceptual contrast data for /ɔ/ vs /o/

/ɔ/	Response= YES	Response= NO	TOTAL
Signal= PRESENT	HIT 141	MISS 83	224
Signal= ABSENT	FALSE ALARM 34	CORRECT REJECTION 246	280
TOTAL	175	329	504

The result of the sensitivity between /ɔ/ vs /o/ (d') is presented here[1].

Table 9: The perceptual contrast data for /ε/ vs /e/

/ε/	Response= YES	Response= NO	TOTAL
Signal= PRESENT	HIT 106	MISS 62	168
Signal= ABSENT	FALSE ALARM 27	CORRECT REJECTION 86	113
TOTAL	133	148	281

The result of the sensitivity between /ε/ vs /e/ is presented here[2].

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[1] HIT= 141/224= .629
Z (HIT)= z (.629) = .329
FA= 34/280= .121
Z (FA)= z (.121) = -1,170
Sensitivity:
d'= z (HIT) – z (FA)
= .329 – (-1.170)
= 1.499

The values of bias for the perceptual contrast between /ɔ/ vs /o/ and the bias for the perceptual contrast between /ɛ/ vs /e/ are respectively presented here.[3]

3.4.4 T-test results

A t-test was run to determine the degree of sensitivity differences for the perceptual discrimination between the pairs of vowels /ɔ/ and /o/, and /ɛ/ and /e/ respectively. The d-prime of each individual for the perceptual contrast between /ɔ/ and /o/, and /ɛ/ and /e/ was respectively computed and compared. The t-test was therefore computed to determine whether their sensitivity to perceptually discriminate between those pairs of vowels is significant.

As of the perceptual discrimination between /ɔ/ and /o/, I posit as the null hypothesis (Ho) that there are no differences between the d'/ɔ/ and d'/o/. The alternative hypothesis predicts that there are differences between the d'/ɔ/ and d'/o/. The research hypothesis are as: Ho: d'/ɔ/ = d'/o/, and H1: d'/ɔ/ ≠ d'/o/.

Since the p-value is smaller than alpha [$t(55) = 4.462$, $p < 0.001$], I reject the null hypothesis which predicted that d'/ɔ/ is equal to d'/o/ (d'/ɔ/ = d'/o/). Therefore, I confirm the alternative hypothesis which assumed that d'/ɔ/ is different from d'/o/. This implies that

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[2] HIT= 106/168= .630
Z (HIT)= z (.630) = .332
FA= 27/133= .203
Z (FA)= z (.203) = -0,831
Sensitivity:
d'= z (HIT) – z (FA)
= .332 – (-0.831)
= .332 + .831
= 1.163

[3] Bias:
The formula for bias is:
Bias = -1/2 (z (HIT) + z (FA))
The bias for the perceptual contrast between /ɔ/ vs /o/
Bias = -1/2 (.329 + (-1.170))
= -1/2 (.329 – 1.170)
= -1/2 (- 0.841)
= - 0.5 (- 0.841)
= .421
The bias for the perceptual contrast between /ɛ/ vs /e/
Formula: Bias = -1/2 (z (HIT) + z (FA))
= - 1/2 (.332 + (- 0.831))
= - ½ (.332 – 0.831)
= - ½ (- 0.499)
= - 0.5 (- 0.499)
= .250

KL speakers' sensitivity to discriminate between the pairs of vowels /ɔ/ and /o/ is significantly different. They perceive /ɔ/ as such and /o/ as such. However, their abilities to perceive /o/ is significantly different from the abilities to perceive /ɔ/.

I have further computed the Welch Two Sample t-test to determine whether there are differences between the d'/ɔ/ and d'/o/in terms of KL speakers' gender. I have posited as the null hypothesis (Ho) that there are no differences between male and female KL speakers in their abilities to discriminate between the pairs of vowels /ɔ/ and /o/. The alternative hypothesis, however, has assumed that there are differences between male and female KL speakers in their abilities to discriminate between the pairs of vowels /ɔ/ and /o/.

The result [$t\ (35.69) = 1.432$, $p = 0.16$] shows that there are no significant differences between male and female speakers of KL in their degree of sensitivity to discriminate between the pair of vowels /ɔ/ and /o/ in KL.

I have computed the Welch Two Sample t-test to determine whether there are any differences in terms of age in discriminating the perceptual contrast between the vowels /ɔ/ and /o/. I have assumed that as the null hypothesis that there are no differences between the d'/ɔ/ and d'/o/. The alternative hypothesis predicted that there are differences between the d'/ɔ/ and d'/o/.

The result of the Welch Two Sample t-test, with reference to age as a variable, has determined that age plays an important role in determining their sensitivity to discriminate between those two vowels. The result [$t\ (54) = -1.4359$, $p = 0.156$] shows that there are significant differences between the d'/ɔ/ and d'/o/ in terms of age. This implies that there are significant differences in age between KL speakers who are older than 35 years old as opposed to those who are younger than 35 years old in their abilities to discriminate the perceptual contrast between the pair of vowels /ɔ/ and /o/ in KL.

On the other hand, the t-test was as well computed to determine whether there are any significant differences between the d'/ɛ/ and d'/e/. The null hypothesis predicted that there are no differences between the d'/ɛ/ and d'/e/. Whereas, the alternative hypothesis assumed that there are differences between the d'/ɛ/ and d'/e/. The results [$t\ (55) = 9.3715$, $p < 0.001$], have shown that d'/ɛ/ is not equal to d'/e/. This entails that there are significant differences in terms of KL speakers' sensitivity to discriminate the perceptual contrast between the pair of vowels /ɛ/ and /e/. This indicates that they perceive /ɛ/ neatly different from /e/ in KL.

Some ad hoc computing has been done to determine whether the sensitivity of male speakers as compared to female ones in relation to their abilities to discriminate the perceptual contrast between the pair of vowels /ɛ/ and /e/ is significantly different. The results [$t\ (43.678) = 11.226$, $p < 0.001$] have shown that there are significant differences between the d'/ɛ/ and /e/. This entails that KL male speakers' sensitivity to discriminate the perceptual contrast between the pair of vowels /ɛ/ and /e/ is significantly different from those of females.

Finally, I computed in relation to KL speakers' age to determine whether their sensitivity to discriminate the perceptual contrast between the pair of vowels /ɛ/ and /e/ could vary depending on their age range. I posited as the null hypothesis that KL speakers' sensitivity to discriminate the perceptual contrast between the pair of vowels /ɛ/ and /e/ is the same. The alternative hypothesis predicted that KL speakers' sensitivity to discriminate the perceptual contrast between the pair of vowels /ɛ/ and /e/ is different. The results [t (48.445) =8.858, $p < 0.001$] have confirmed the alternative hypothesis which predicted that the sensitivity of KL speakers who are older than 35 years old is different from that of those who are younger than 35 years old.

4. Discussion and findings

The general results on the perceptual contrast between /ɔ/ and /o/ have shown that KL speakers perceptually discriminate between /ɔ/ vs /o/. Their abilities to perceive the vowel /o/ (Right answers: 87.8%, Wrong: 12%) is more efficient than their abilities to perceive /ɔ/ (R: 62.9%, W: 37%). There were no differences between male and female KL speakers in their abilities to discriminate between /o/ and /ɔ/.

As of the discrimination between /e/ and /ɛ/, it was determined that KL speakers perceive the differences been the vowels /ɛ/ and /e/. They are more accurate in perceiving the vowel /e/ (R: 76.1%, W: 23.8 %) than in perceiving /ɛ/ (R: 63%, W: 36.9%). Gender wise, male speakers of KL were more accurate (R: 56.9%) in perceiving /e/ than female speakers (R:43%). In the same line, male speakers of KL were also more accurate in perceiving /ɛ/ (R: 54.7%) than female speakers (R: 45.2%) were. Overall, male speakers were more accurate in perceiving /e/ and /ɛ/ than female speakers were. With reference to age as another variable, there were no differences between speakers who were older than 35 years old as compared to those who were younger than 35 years old in perceiving the vowels /ɛ/ and /e/.

The results of the Signal Detection Theory have revealed the sensitivity of KL speakers in discriminating the perceptual contrast between the pairs of vowels /ɔ/ and /o/, and /ɛ/ and /e/ respectively. Even though it is true that KL speakers are sensitive to discriminate between the pairs of vowels /ɔ/ and /o/, and /ɛ/ and /e/ respectively, their degree of sensitivity varies depending on the vowel. They are more sensitive in perceiving the vowels /o/ and /e/ as opposed to /ɔ/ and /ɛ/. Interpreted in another perspective, it could be said that KL speakers' perceptual skills to /ɔ/ is rather decreasing or fading. However, this perceptual skill fading has not affected their abilities to discriminate the perceptual contrast between the pairs of vowels /ɔ/ and /o/, and /ɛ/ and /e/ respectively.

The findings have further shown that there are no differences between male as opposed to female speakers of KL in their abilities and (degree of) sensitivity to discriminate the perceptual contrast between the pairs of vowels /ɔ/ and /o/, and /ɛ/ and /e/ respectively. This means that gender differences as a variable do not play any role in determining KL speakers' abilities to discriminate the perceptual contrast between the the aforementioned pairs of vowels. Male and female KL speakers have, thus, the same sensitivity in discriminating between the aforementioned pairs of vowels.

On the other hand, the results have shown that age is an important factor in determining the sensitivity of KL speakers to discriminate the perceptual contrast between the pairs of vowels /ɔ/ and /o/, and /ɛ/ and /e/ respectively. It was found that KL speakers who are older than 35 years old are more sensitive to discriminate between the pairs of vowels /ɔ/ and /o/, and /ɛ/ and /e/ respectively than are those folks who are younger than

35 years old. Event though these two groups of age are sensitive to those pairs of vowels, it is clear that the sensitivity of younger people is actually decreasing or fading.

5. Conclusion

The aim of this study was to test the abilities of KL speakers to discriminate the perceptual contrast between the pairs of sounds /ɔ/ and /o/ and ɛ/ and /e/ respectively. The null hypotheses of this research predicted that KL speakers do not discriminate between /ɔ/ and /o/ and ɛ/ and /e/ respectively. The alternative hypotheses, however, claimed that KL speakers do discriminate between the pairs of vowels /ɔ/ and /o/ and ɛ/ and /e/ respectively. The null hypotheses of the study were formulated in line with the claims in the existing literature that KL speakers do not discriminate between the two aforementioned pairs of vowels respectively (Campbell and King 2013, Montingea 2006, Bokamba 2012). Their claims in the literature have never been clear whether the neutralization they claim is perceptual or articulatory. I assigned myself the mission, in this study, to test KL speakers' abilities to perceptually discriminate between /ɔ/ and /o/ and ɛ/ and /e/ respectively.

The findings of this study have challenged the claims in the literature that KL speakers do not discriminate between the pairs of vowels /ɔ/ and /o/ and ɛ/ and /e/ respectively (Campbell and King 2013, Montingea 2006, Bokamba 2012). The study has determined that KL speakers do perceptually discriminate between the pairs of vowels /ɔ/ and /o/ and ɛ/ and /e/ respectively. This implies that whenever a minimal pair is produced in KL, KL speakers can make the differences between the pair based on their segmental differences which is determined by the quality of the vowels /ɔ/ and /o/ and /ɛ/ and /e/ respectively.

The results have shown that their abilities to perceive /e/ and /o/ as opposed to /ɛ/ and /ɔ/ respectively is more efficient. In other ways, KL speakers' abilities to perceive /ɛ/ and /ɔ/ is less accurate than the abilities to perceive /e/ and /o/. While gender does not play any role, it is found that age as a variable plays an important role in determining the sensitivity to discriminate the perceptual contrast between the pairs of the vowels under this study.

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