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EFFECT OF SPEAKERS' GENDER ON VOICE ONSET TIME AND CLOSURE DURATION IN ENGLISH STOPS PRODUCED BY HAUSA NATIVE SPEAKERS

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Abstract

The study's goal was to quantify native Hausa speakers' Voice Onset Time (VOT) and Closure Duration (CD) of English stops, with an emphasis on gender variations. Determining the VOT values and CD of the English stop sounds /p/, /b/, /d/, /t/, /k/ and /g/ was the stated goal. Additionally, the impact of gender on the target consonants' VOT values and CD was ascertained. Thirty students in total—fifteen males and fifteen females—were enlisted at Bauchi State University in Gadau to participate in this study. Purposive sampling served as the basis for choosing the participants. This study, which is non-experimental, used speech recordings and a quantitative approach to ascertain the acoustic features of non-native sounds among native Hausa speakers. The task required them to pronounce words that were disyllabic and contained the target sounds while recording their speech with a microphone headset and the PRAAT program. Additionally, a demographic questionnaire was employed to narrow down the population such that only Hausa native speakers would be included in the samples. By determining whether the data was normal, the production task's data was analysed acoustically with SPSS (Version 22). It was discovered that the usage of different vowels had no effect on the VOT's range; nevertheless, the vowels were said to have an impact on the ranges of the three voiceless plosives, /t/, /k/, and /p/. Additionally, it was discovered that the voiced plosives /b/ and /d/ had negative Voice Onset Time based on their spectrograms and waveforms.

Keywords: Voice Onset Time, Closure Duration, Gender, English Stop Sounds, Hausa Native Speakers

Introduction

When producing stop consonants, the airflow is completely blocked in the mouth by the lips, tongue-tip, or tongue-back, and then released with a sudden burst (O'connor, 2000). Stop sounds are present in all languages around the world and are considered to be the most common consonants in a language (Kent & Read, 2002). In Hausa, the stop sounds include /b/, /t/, /d/, /k/, /g/, /ɗ/, and /ɓ/ (Sani, 2005).

Voice Onset Time is the moment before the next vowel begins when the vocal-fold vibrates due to the release of a closure. For voiced plosives, for example, there is a pause before the voicing begins and the vocal apparatus vibrates continuously. Conversely, the aspirated plosives that lack a voice have a significantly longer latency. Language to language differs in the degree of delay between plosive kinds (Crystal, 2008).

Waveform and spectrogram are usually used in VOT measurement, according to Abramson and Whalen (2017). The time delay (measured in milliseconds) between the start of phonation and the brief noise burst of stop release is known as the VOT.

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Print ISSN: 2992-4979
Online ISSN: 2992-4987

According to Lisker and Abramson (1964), VOT values are positive when phonation commences after stop release (voicing lag) and negative when phonation comes before stop release (voicing lead).

As defined by Lisker (1957: 45), CD is the "interval between the end of the vowel-formant transition preceding the stop and the onset of the transition to the following vowel". Voiceless stops are supposed to have a longer CD phonologically than voiced stops, which are said to have a shorter CD. According to Lisker (1957), voiceless /p/ has a length of 120 ms on average, which is longer than the closure of voiced /b/, which is 75 ms. Vicenic (2010) examined the acoustical stops of voiced, voiceless, and ejectives in Georgian and Caucasian languages. The three types of stops that can be distinguished by auditory properties were the main focus of the investigation. The results of the CD's acoustic testing showed that the pauses at the starting places take longer—71 ms—than the stops at the medial positions (56 ms).

Various studies have been conducted in the field of VOT and CD, according to the prior relevant literature evaluation. However, there has not been much research done on this aspect of Hausa language, especially when it comes to how gender affects non-native speakers' perception and output. According to a study by Abdullahi (2018), the sounds in Hausa have a wide range of VOT and CD values. He also looked at the VOT values and CD of plosives and implosives.

Abbasi et al. (2022) examined the temporal voice onset time (VOT) of consonantal stops between the release burst of stops and the voice box's onset of vibration. The voice onset time of L1 Sindhi and L2 English stops is investigated acoustically in this work, and was the first attempt according to the author. Determining the Voice Onset Time (VOT) acoustic average values for stop consonants in Sindhi English, or L1 and L2 speech production, is the aim of the study. Ten participants—five females and five males—who were native Sindhis and English as a second language (ESL) learners were enrolled in the study. Three pairs of voices, one each in Sindhi and English, were chosen for the stimuli. Six Sindhi and English voicing stop pairs (one voiceless and one voiced) /p/, /t/, /k/ & /b/, /d/, and /g/ were measured for VOT (ms). The voice samples were recorded by the undergraduate students in both English and Sindhi. The data were analyzed independently in English and Sindhi. There were auditory differences for both Sindhi and English within and between the groups in VOT (ms). A fixed p-value significance level of less than 0.05 was applied to the statistical test results. The results demonstrate a considerable difference in the means of the voiceless sounds, /p/ and /k/. The data findings indicate that there is no statistically significant difference between the VOT (ms) averages of males and females for voiceless and voiced consonantal sounds, such as /t/, /b/, /d/, and /ʔ/. The findings also showed that the position of articulation altered the English Sindhi VOT rather than gender being a factor in the features of stops in the language.

In another study by Macleod and Stoel-Gammon (2005), the VOT of Canadian English speakers was investigated. They adhered to the same protocol as suggested by Lisker & Abrahamson (1964), i.e., using spectrograms and waveforms. The voiceless stops /p/ and /t/, as well as the voiced stops /b/ and /d/, were recorded, and the mean Voice Onset Time value was obtained for each participant. The outcome reveals that the VOT for /b/ and /d/ was 87.9 ms, whereas the VOT for /p/ and /t/ was 19.8 ms.

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Kessinger and Blumstein (1997) conducted additional research on the VOT value of four English speakers. They discovered that the values for /p/, /t/, /b/, and /d/ were 85, 100, 15, and 20 ms, respectively. Eight English speakers' Voice Onset Times were measured. The measured voiceless /p/, /t/, and /k/ were 62.5, 71.9, and 74.8 ms, respectively. Conversely, Caruso and Burton (1975) measured the voiced stops /b/, /d/, and /g/ as well, and discovered that they were 19.7, 21.4, and 35.2 ms, respectively. Macleod and Stoel-Gammon (2005) assessed the mean Voice Onset Time value of three speakers who were Canadian French speakers. The results of the study showed that the voiced stops /d/, /b/ and voiceless stops /t/, /p/ were determined to be 37.4 ms and -99.3 ms, respectively.

Lisker and Abrahamson (1964) also looked at Thai speakers' VOT values. Following the participation of three Thai speakers, the results indicated that the corresponding /p/, /t/, /k/, /b/, and /d/ were 6, 9, 25, -97, and -78 ms. Kessinger and Blumsten (1997) conducted a similar study in which they looked at the VOT values of four Thai speakers. The results indicate that the values for /d, /b/, /t/, and /p/ were -65, -70, 13, and 15 ms, respectively.

Jones and Meakins (2013) investigated the variation in VOT of conversational speech and picture naming by Gurindji Kriol speaking women in recent VOT research. The results demonstrate that, at least up to 30 ms, pauses that appear at the beginning places typically feature short-lag VOT. The VOT of stops that arose at the word-medial places is negative. Similarly, Yanagida, Mizogushi, Hatakeyama, and Fukuda (2015) compared the Voice Onset Time between the two patient groups (Abductor Spasmodic Dysphonia (ABSD) and Adductor Spasmodic Dysphonia (ADSD)) for voiceless /t/ at the word-initial position. In comparison to the other patient group (ADSD), the results indicate that ABSD patients had longer VOT.

Table 1 Mean VOT Values of Previous Studies

Languages	Sounds and VOT Values					
	/b/	/d/	/p/	/t/	/k/	/g/
English	1	5	58	70	80	21
Turkish	66	53	41	50	69	10
Dutch	-85	-80	10	15	25	-
Thai	-97	-78	6	9	25	-
Spanish	-138	-110	4	9	29	-108
Tamil	-74	-78	12	8	24	-62
Hungarian	-90	-87	2	16	29	-58
Cantonese	-	-	9	14	34	-
Canadian	87	88	19	19	-	-
Mandarin	-	-	100	99	110	-
Taiwanese Chinese	-	-	18	19	28	-

Gender and Voice Onset Time

In the literature, gender variations in voice onset time have not gotten much attention. This is unexpected given the distinctions in articulators seen in prior studies between speakers who identify as male and female. For example, Zhang's (2021) summary of data indicates that the average vocal fold membrane length in adult females is 6 mm shorter

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than in adult males. The likelihood of a quicker closing gesture is heightened by a shorter membranous length, as seen by the greater average f0 value in female speaking as opposed to male speech. As a result, if the vocal folds' abduction speed influences voice onset time (Kewley-Port & Preston 1974), then this element would have different effects on male and female plosives, resulting in gender bias.

It is commonly recognized that voice onset time (VOT) plays a crucial role in both speech production and perception. In English and many other languages, VOT is a dependable cue to distinguish between voiced and voiceless stops. Using the respiratory, phonatory, and articulatory structures' fine motor coordination, VOT functions as an audio cue and an inferential assessment of speech motor control.

Children, the elderly, people of all races, non-English speaking people, and people with speech disorders have all had their VOT scores assessed. Gender's impact on VOT has also been investigated. Studies from the past suggest that males and girls produce word-initial stop consonants differently, and that these differences can be seen as early as age 11. The research by Whiteside and Marshall (2001), which found no gender differences among adult speakers, and Ma, Wu, Chen, and Zhang (2018), who saw longer VOTs for initial /d,g/ in adult men, are the exceptions to these findings. Generally speaking, compared to males, females create stops with longer VOT durations.

The reasons behind speech impairments in Parkinson's disease (PD) are still poorly understood, according to recent research by Rusz et al. (2022), with the majority of the evidence coming from male patients. The aim of the study was to investigate the correlation between gender and dopamine transporter imaging and the prevalence and characteristics of speech impairments in early-stage, drug-naive Parkinson disease patients. Speech samples from 60 male and 40 female age-matched healthy controls and 60 male and 40 female de novo Parkinson's disease patients were analyzed. Acoustic vocal analysis was used to objectively evaluate ten distinct speech characteristics related to prosody, articulation, phonation, and speech duration. The Montreal Cognitive Assessment [123] and I-2b-carbomethoxy-3b-(4-iodophenyl)-N-(3-fluoropropyl) nor tropane single-photon emission computed tomography were utilized to evaluate each subject. Speech deficits were common (56% in male patients and 65% in female patients) in the de novo PD group, with the most common presentations being monopitch, monoloudness, and articulatory decay. Discrimination between PD and controls was made possible by automated speech analysis, with an area under the curve of 0.93 for women and 0.86 for men. In de novo PD, no gender-specific speech impairment was discovered. Regardless of the state of the illness, females performed better than men in terms of voice quality and the ability to produce pauses—males performed better only in terms of loudness fluctuation.

The VOT values of the word-initial /p/ and /b/ bilabial as perceived by Arabic-speaking male and female Saudi ESL learners, were investigated by Alsuhaim (2022). It aimed to determine whether there were any variations in this acoustic metric (i.e., VOT) between these two groups. The contrastive analysis (CA) hypothesis was subsequently tested by comparing the VOT values with those of native English speakers. The recordings of the 20 participants—10 females and 10 males—were used to calculate the VOTs. The Praat speech analysis software was utilized in this investigation to calculate the VOT values. The findings showed a statistically significant difference in the participants' VOT values

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for /b/ between the male and female groups. There was no statistical difference observed in the results for the VOT values of /p/. Additionally, when comparing the male participants' VOTs for /b/ to those of native English speakers, an increase was noted. The remaining findings, which showed that both sexes learned the voiceless phoneme /p/ even though their native language (Arabic) did not have it, were largely consistent with the VOT values of native English speakers.

Jang (2022) investigated how the genders employed the acoustic cues across different prosodic positions and attention situations, as well as whether there was a gender influence on the phonetic features of Korean stops in the Kyungsang dialect. at both focused and unfocused settings, as well as at the initial and medial positions of IP, voice onset time, fundamental frequency peak, and vowel duration were compared. It was discovered that Kyungsang male speakers had longer VOT values for lenis and aspirated stops than did female speakers. The female speakers had longer vowels, higher F0 and semitones at both stops than the male speakers did, and the systematic variation in semitones based on distinct prosodic circumstances was limited to the speech of the female speakers. The Kyungsang female speakers placed greater emphasis on using F0 to contrast the stops across the various prosodic situations, whereas the Kyungsang male speakers used VOT to distinguish stop categories.

With a focus on the viewpoint of women, Thorsen and Johannessen (2023) examined the significance, nature, and workload of providing intense care for wives or partners suffering from young-onset frontotemporal dementia (YO-FTD) based on the experiences of spouses. In 2014 and 2015, a qualitative Norwegian study was carried out with the help of narrative interviews with 10 wives and 6 husbands. Four gender-related primary themes emerged from the analysis: varying times of caregiving, social isolation, needing support and respite, and distancing: observing a changed partner and relationship. A case analysis was conducted on the tales of women and men, with a particular emphasis on the wife's story, in order to investigate the intricate connections between living circumstances, care obligations, experiences, and responses. The responsibilities and customs of gendered caregiving have an impact on spouse care. The study discovers significant variations in the meaning, content, and sustainability of care, as well as in the support needs, between spouses. Wives are more likely to have their demands disregarded and have experienced longer periods of stress than husbands. This has a detrimental emotional impact and affects their health. Husbands were able to get public help early and with greater efficiency by presenting their requirements. When caring for a spouse with YO-FTD, women may require additional support at an earlier stage. To live their own lives and maintain their identities, they require person-centered, gender-sensitive support.

All voice disorders were substantially more common in women. There was no difference in the mean time-to-diagnosis (the amount of time before a medical consultation) between males and females. The two groups' rates of treatment rejection and VT adherence (mean number of absences and early dropout) were comparable. Women had lower pre-VT VHI and "G" parameter values. There was a noticeably greater proportion of women with aberrant acoustic analysis. Women had more post-VT VHI gain, but there was no sex-specific difference in the "G" parameter improvement. According to our study, voice problems are more common among women. The awareness of dysphonia was independent

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of gender. Women initially had lower voice subjective perception and acoustic analysis scores, but following therapy, they felt that their voices had improved more.

It has been shown that there are gender variations in the laryngeal, supralaryngeal, and respiratory functions related to speech production. The gender disparities in VOT production are likely due to underlying biological variations in the different speech subsystems. For instance, compared to male productions, female prevocalic stop productions are linked to higher oral pressure. Female phonation is characterized by a posterior glottal opening, or "chink," that happens during vocal fold closure, according to Bless and Abbs. When the vocal folds close, air leaks into the supralaryngeal area as a result of this opening. It's probable that, in the case of female VOT production, more air escapes into the supralaryngeal space before vowel formation, leading to higher oral pressure for stops when compared to male speakers. The prolonged time lag between the start of voice and the stop burst is caused by the increased mouth pressure.

Previous studies looking into gender differences in VOT have not included the effect of speaking rate. Therefore, rather than biological differences, the sex-linked VOT pattern can be produced by variances in speaking tempo (such as word duration). Variations in VOT between genders could also be caused by the way that VOT values are summed up. A popular technique for calculating and reporting value at risk (VOT) is to average the values of short-lag and voicing-lead (i.e., negative VOTs). Since Lisker and Abramson employed this procedure for the first time in 1964, other researchers have also embraced it. However, computing mean VOT values on both positive and negative values may obscure possible patterns in the generation of VOT, particularly in the generation of voiced stops. Examining short-lag VOT values separately from negative VOTs may highlight gender differences in VOT that have not been identified before.

Lastly, there have been proposals that the sociophonetic impact could explain the disparities in VOT between the sexes, explaining how speech patterns are deliberately altered to either explicitly or implicitly express gender identity. According to Cheshire (1998) and other researchers, there is a general pattern of pronunciation difference between males and females. In experimental circumstances, females tend to utilize more carefully articulated speech. No systematic efforts have been made to ascertain if societal factors could be responsible for gender variations in VOT.

Closure Duration

As defined by Lisker (1957: 45), CD is the "interval between the end of the vowel-formant transition preceding the stop and the onset of the transition to the following vowel." Voiceless stops are supposed to have a longer CD phonologically than voiced stops, which are said to have a shorter CD. According to Lisker (1957), voiceless /p/ has a length of 120 ms on average, which is longer than the closure of voiced /b/, which is 75 ms. Flege (1995) examined the acoustical stops of voiced, voiceless, and ejectives in Georgian and Caucasian languages. The three types of stops that can be distinguished by auditory properties were the main focus of the investigation. The results of the CD's acoustic testing showed that the pauses at the starting places take longer—71 ms—than the stops at the medial positions (56 ms).

Numerous studies that have been published have described CD. For instance, Naidoo (2010) conducted an experimental study on the implosive /b/ in Zulu. In comparison to

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plosive /b/, voiced implosive /b/ has a longer CD, according to the acoustic result. The outcome demonstrates that voiced implosive and voiced plosive can be distinguished primarily by CD.

Word-medial stops in languages other than English; phonologically voiced stops typically have shorter closures than voiceless stops. The mean difference in isolated words was found to be 38 ms in Polish and 28 ms in Dutch (Slis & Cohen, 1969; Keating, 1980). The mean difference in the sentence condition was 46 ms in Portuguese and 5-8 ms in French (Jacques, 1987). (Lousada et al., 2010). The same association was discovered in the sentence frame's word-final position, where there was a smaller but statistically significant difference of 21 ms in French and a mean difference of 47 ms in Portuguese (Lousada et al., 2010). (Abdelli-Beruh, 2004). German results are not constant. Jessen (1998) discovered that word-medially closures of phonologically voiced stops were noticeably longer. Fuchs (2005) found the same thing for the pair /d/-/t/ in post-stressed, but not stressed, position. Word-finally, there were no significant differences found by Fuchs (2005) and Smith, Hayes-Harb, Bruss, and Harker (2009); however, most of the speakers in Brunner's (2005) study produced /g/ closures, which were noticeably shorter than /t/ closures. According to research, phonologically voiced stops in French have closures that are, on average, 22 ms shorter than phonologically voiceless stops (Abdelli-Beruh, 2004). The same was reported for Arabic, with a mean difference of roughly 10 ms (Flege & Port, 1981), and Portuguese, with a mean difference of 55 ms (Lousada et al., 2010).

Word-initially phonologically voiced stops in an English continuous speech have longer closures than their voiceless counterparts, according to Crystal and House (1988a); word stress influences Umeda's (1977) mixed pattern. Although Byrd (1993) found that closures of phonologically voiced stops were 7 ms shorter (a significant result), and Crystal and House (1988a) found a negligible difference in CD of their complete stops, pooled results for stops in all word positions in continuous speech suggest that the overall difference in CD is rather small or disappears.

Following these production results, a number of perceptual studies discovered that, for example in Dutch (Slis & Cohen, 1969a) and English (Liberman, Harris, Eimas, Lisker, & Bastian, 1961; Lisker, 1957), synthetic and edited natural stimuli with silent closures were perceived as containing voiced stops if closures were shorter and as containing voiceless stops if closures were longer. When speaking at a faster rate, less silence was required for a voiceless perception because the perception of medial stops in English was sensitive to changes in speaking tempo in the carrier sentence before it (Port, 1979).

According to the results of the research discussed in the penultimate paragraph on CD, "Closure Duration" is a crucial auditory cue for recognizing and separating stop consonant classes. According to the studies, voiceless stops have longer CD than voiced stops. Stops at a word's beginning are lengthier than stops at the word's middle locations. Similarly, the research' conclusions show that CD can be used as a cue to distinguish between voiced and voiceless stops. These results would be pertinent to the current investigation because they shed light on CD characteristics as well as voiced and voiceless stop waveforms and spectrograms.

http://www.lijassed.org
Print ISSN: 2992-4979
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There is a dearth of literature on speech production and CDs, which is why educators need further study on this crucial subject. There are currently no research that look at the gender differences in the stop sound production of Hausa native speakers of English. Examining the plosive lengths is crucial since it will highlight the differences between the sounds. This will make it easier for speakers of Hausa and other languages with plosives to watch how they pronounce words. Additionally, no empirical research has been done on the acoustic measures of English stops made by native Hausa speakers. An extra auditory cue is required, and CD was determined to be appropriate. This acoustic cue may also be helpful when comparing the production by native Hausa speakers and imitation attempts by naïve speakers of English stops.

Docherty (1992) discovered that CD for /b/ is shorter than /p/, /g/, and /k/ for initial stops in English, while the opposite is true for the pair /d/-/t/. According to Stathopoulos and Weismer (1983), in the word-initial stressed position, closures of phonologically voiced stops were longer, while in the word-initial unstressed position, they were equal or shorter. Fischer-Jørgensen (1954) discovered that stops in Danish with phonological voice had noticeably longer closures (with mean differences ranging from 26 to 45 ms).

All things considered, the preceding makes a strong argument for determining how gender affects English VOT and CD among Hausa natives. It is thought that this discovery served as the foundation and justification for the current study's methodology. It is therefore anticipated that this study will contribute to filling the vacuum in the literature about non-native phonetics and phonology.

The following are the study's particular objectives:

1. To determine the Voice Onset Time values (VOT) of English stops /p/, /k/, /b/, /d/, /t/ and /g/ produced by Hausa native speakers.
2. To determine the Closure Duration (CD) of English stops /p/, /k/, /b/, /d/, /t/ and /g/ produced by Hausa native speakers
3. To investigate the effect of gender on the Voice Onset Time values (VOT) of /p/, /k/, /b/, /d/, /t/ and /g/ produced Hausa native speakers.
4. To investigate the impact of gender on the Closure Duration (CD) of /p/, /k/, /b/, /d/, /t/ and /g/ produced Hausa native speakers.

Methodology

This study is a non-experimental study, which will employ a quantitative method using speech recordings, to determine the acoustic information, of non-native sounds among the Hausa native speakers.

Population and Sampling

Students from several faculties at Sa'adu Zungur University, Bauchi State (SAZU) were the study's participants. The participants reportedly began studying English in elementary school at the age of eight. Thirty students in all, fifteen males and fifteen females, with ages ranging from twenty-one to twenty-eight and a mean of twenty-four (24), took part in the study.

http://www.lijassed.org
Print ISSN: 2992-4979
Online ISSN: 2992-4987

Purposive sampling was used to choose the study's volunteers. According to Dattalo (2008), this approach involves the selection of elements based on the researcher's assessment of their ability to facilitate access to the necessary information. Because they were thought to be suitable for the study, students who are native Hausa speakers were found and chosen for it. The Hausa native speakers are expected to speak and understand their native languages more accurately and fluently.

Research Instruments and Materials

The first task utilized to gather data for this study was the voice production task. Pronouncing disyllabic words containing the target sounds while recording their utterances with the PRAAT program and a microphone headset was required for the task. The target sounds used in the task are /b/, /d/, /p/, /b/, / t/, and /g /. The same recorded words were used for acoustic measurements.

The following table displays the stimuli used in the production task.

Table 2 Stimuli used in the study

Vowel/consonant	/p	/t/	/k/	/g/	/d/	/b/
/a/	pat	Tap	cat	gap	dark	bag
/i/	pit	Tip	kit	geese	dig	big
/o/	pot	Top	coat	got	dot	boat
/u/	put	took	cool	good	do	book
/e/	pet	take	case	get	dat	beck

For every consonant in the production task, the prior study employed four or more different words (Ogut et al., 2006). The target phoneme appears at the beginning of each word in the speech production investigation, which included monosyllabic, dissyllabic, and occasionally trisyllabic syllables (Abdullahi, 2018). Thirty (30) English monosyllabic words were selected and employed in the current investigation.

Every recording of the stimuli uses a condenser microphone. This kind of microphone is usually utilized in situations when exact measurements are necessary. A condenser microphone's frequency response typically stretches from 20 to 20,000 Hz, and it is quite flat. These microphones have the capacity to record at frequencies as high as 100,000 Hz. Additionally, the microphone amplifies the signal through its small amplifier attached to it (Decker & Carrell, 2004). Logitech Wireless Headset h600 has the same features.

Procedures of the Production Task

In order to improve the production, the participants were first invited to a quiet room. They use headphones (Logitech Wireless Headphone h600) to produce the words with the target sounds (stops) while sitting alone in a quiet environment. Individual instructions were given to them to utter the words containing the target stop sounds while the recording was being made with a Logitech condenser microphone and PRAAT software.

Demographic Questionnaire

As previously mentioned, in order to find participants, a purposeful sampling technique was initially used, which was based on the answers to the demographic questionnaire. In

http://www.lijassed.org
Print ISSN: 2992-4979
Online ISSN: 2992-4987

this study, the population was filtered using the demographic questionnaire to ensure that the samples consisted of Hausa native speakers. Eliminating speakers who did not speak Hausa as their native tongue required population filtering. The language used to write the background questionnaire was English. Participants in the study were first given a background questionnaire to complete. Before beginning the production task, the participants answered the background questionnaire.

The respondents/participants were questioned about their native background, knowledge of other languages, linguistic history, background in linguistics, and instruction in both Hausa and English, in addition to their gender and names. The questionnaire included a different variety of questions about the non-native friends, family, acquaintances, and other related questions.

Data Analysis

The first data collected in this study is the demographic questionnaire, followed by the second one which was collected from the production test.

The data collected from the demographic questionnaire was used to obtain the participants' age mean, native language background, language used for interactions, and other related questions.

The data collected from the production task from the subjects was analysed acoustically using SPSS (Version 22) by testing the normality of the data. SPSS independent samples t-test, paired samples t-test, and Pearson's Correlation Moment was used to test the significance (at .05 level of significance) differences between the mean scores of the two variables of the study.

Results

Voice Onset Time for English Plosives Produced by Hausa Native Speakers

This section describes the Hausa's VOT of plosives /b/, /d/, /t/, /g/ and /p/. According to Abramson and Whalen (2017), VOT measurement typically relies on waveform and spectrogram. The measurements of the plosives were done based on wideband spectrogram which was recommended by Lisker and Abramson (1964). Based on that, each of the Hausa native speakers produced 20 different words which contain the target plosives at the initial positions of the words. Each plosive was combined with five different vowels /a/, /i/, /e/, /o/, and /u/. A total number of nine hundred (900) words were analysed in order to find out the VOT values of English stops produced by the Hausa native speakers.

Table 3 presents the mean of VOT values in milliseconds for the five English plosive consonants combined with the five different vowels.

http://www.lijassed.org
Print ISSN: 2992-4979
Online ISSN: 2992-4987

Table 3 Mean of VOT values in milliseconds of English plosives combined with the five vowels produced by Hausa native speakers

Sounds	/a/	/i/	/e/	/o/	/u/	Mean VOT	VOT Range	
							Minimum	Maximum
/b/	-17.56	-22.18	-21.27	-22.80	-22.53	-20	-20.20	-22.80
/d/	-23.53	-23.78	-23.82	-22.18	-21.51	-22	-21.60	-24.00
/t/	12.62	34.64	18.27	12.98	13.67	18	16.60	23.20
/p/	30.16	38.69	25.98	34.71	49.27	36	26.00	45.60
/g/	31.12	41.43	24.44	38.44	52.21	38	27.00	47.23

The English VOT values for the various vowels are shown in the above table. The range of the two voiced plosives, /b/ and /d/, is -20 to -22. This demonstrates that the various vowels employed had no effect on the VOT's range; yet, the vowels were claimed to have an impact on the VOT's ranges for the three voiceless plosives, /t/, /g/, and /p/. The mean of each plosive's vowels was added to determine the Voice Onset Time values for the English plosives.

Voice Onset Time Categories for English Stop Consonants Produced by Hausa Native Speakers

Because the voicing for the vowel starts before the burst, it was discovered that the voiced plosives /b/ and /d/ have negative Voice Onset Time values (voicing lead or prevoicing). Furthermore, the articulatory release of supraglottal occlusion, also known as voicing lead or prevoicing, occurs prior to the glottal line (pulses) (Lisker & Abramson, 1964). The waveforms and spectrographs for the English voiced bilabial plosive /b/ are shown in Figure 4.1. The English VOT values obtained agree with the results of Shahidi and Aman's (2011) acoustic analysis of Hausa speakers' English plosives.

The voiceless alveolar plosive /t/ was discovered to have a brief voicing lag, in contrast to the three voiceless plosives /t/, /g/, and /p/, which have varying ranges of VOT values. Not long following the transitory comes the voicing of the burst of voiceless plosives /g/ and /p/.

Because the voicing for the vowel starts before the burst, the spectrograms and waveforms of the voiced plosives /b/ and /d/ show that they have negative Voice Onset Time values (voicing lead or prevoicing). On the other hand, the voiceless plosives /t/ and /p/ exhibit spectrograms and waveforms that indicate the beginning of voicing follows the transient. According to Lisker and Abramson (1964), these were categorized as "short voicing lag," in which voicing starts soon after the transient. It was discovered that voiceless pauses in both Italian and English belonged to the same group (Lisker & Abramson, 1970). However, the Hausa voiced bilabial plosive /b/'s spectrograph and waveform show that the phoneme has a negative Voice Onset Time. Lisker and Abramson (1964) classified VOT values and found that the Hausa plosive /b/ contains "voicing lead" or prevoicing, meaning that voicing starts before the stop is released. Italian language is one example of a language whose stops fit under this category (Lisker & Abramson, 1971). Similarly, voiced velar stop /g/ in Turkish was discovered to have negative VOT (Ogut et al., 2006).

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Effect of Vowels on VOT Values of Hausa Stops

It was found that only two vowels affected the VOT values. The open front vowel /a/ affects the VOT duration of voiceless plosive /p/. Similarly, the high back vowel /u/ affects the two voiceless plosives /t/ and /p/. Out of the five different vowels used in determining the Hausa VOT values, only two vowels affected the durations. Therefore, vowels only affected voiceless stops in Hausa.

Closure Duration (CD) for English Plosives Produced by Hausa Native Speakers

This section describes the English's CD of plosives /b/, /d/, /t/, /g/, /k/ and /p/. The CD was taken to be the duration between the stop onset and the stop burst of all the sounds. All the measurements of the CD of the plosives were done in milliseconds.

Table 4 Mean of CD values of English stop sounds combined with different vowels produced by Hausa native speakers

Sounds	/a/	/i/	/e/	/o/	/u/	Mean CD	CD Range	
							Minimum	Maximum
/b/	118.71	144.91	125.17	114.56	119.42	125	108	142
/d/	125.04	128.49	111.38	118.42	116.00	120	107	132
/t/	108.13	120.15	135.13	140.20	126.53	126	115	138
/p/	117.31	116.84	116.33	133.20	120.73	121	104	134
/g/	120.11	118.45	119.43	140.32	122.21	123	112	142
/k/	122.12	119.23	119.56	142.34	123.22	124	122	142

The English CD values for voiced and voiceless plosives in respect to various vowels are shown in the above table. The range of the three voiceless plosives, /t/, /p/, and /g/, is found to be between 108, 140, and 142, whereas the two voiced plosives, /b/ and /d/, are found to be between 111 and 145. Of the two voiced plosives, the vowel /i/ was determined to have the highest CD. The back vowel /o/ was found to have the highest CD of the two voiceless plosives. This demonstrates how the CD's ranges were impacted by the various vowels employed. The mean of all the vowels in each English plosive was averaged in order to get the CD values of the plosives.

Effect of Gender on VOT Values of Hausa Native Speakers

The third research topic looked into how gender affected the Voice Onset Time values (VOT) that Hausa native speakers produced for the sounds /p/, /b/, /d/, /t/, and /g/.

The mean VOTs for each consonant produced by males and females in a variety of vocalic contexts are shown in Table 5. It also shows the means and standard deviations of VOT visually drawn for the male and female sexes in various settings involving the vowels a, i, o, u, and e. Table 5 makes it evident that males produced lower VOT values than females for the voiced stops /d/ and /g/. The opposite pattern was observed for the voiceless stops /t/ and /k/, with females' VOTs being longer than males'. Additionally, the VOT values for /d/ were greater than those for the other two vowels when considered in relation to the vowel /a/. The VOTs for the velar stops for the vowels /a/ and /u/ varied between the sexes.

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Online ISSN: 2992-4987

Table 5 Mean VOT values for each stop consonant in varying vowel context separated by gender

Sound	Sex	/a/	/i/	/o/	/u/	/e/	Mean	SD
/b/	Male	16	20	21	21	22	20	3.12
	Female	18	25	24	25	27		
/d/	Male	22	22	20	18	21	22	2.34
	Female	26	26	23	22	25		
/t/	Male	11	27	11	12	17	17	4.32
	Female	15	32	17	16	19		
/p/	Male	28	30	42	36	23	36	3.21
	Female	32	36	47	39	26		
/g/	Male	30	39	31	47	21	38	5.21
	Female	36	45	37	51	29		
/k/	Male	11	36	32	32	30	33	4.21
	Female	18	41	36	38	34		

Effect of Gender on CD of Hausa Native Speakers

The fourth research question aimed at investigating the effect of gender on the Closure Duration (CD) of /p/, /b/, /d/, /t/ and /g/ produced Hausa native speakers.

Table 6 displays the mean CDs for each consonant produced by males and females in a range of vocalic circumstances. The means and standard deviations of CD are also graphically displayed for the male and female sexes in various configurations involving the vowels a, I, o, u, and e in the following picture. It is clear from Table 4.6 that for the voiced stops /d/ and /g/, females produced lower CD values than males. For the voiceless stops /t/ and /k/, the opposite pattern was shown, with female CDs being longer than male CDs. Furthermore, the CD values for /d/ were higher than those for the other two vowels in respect to the vowel /a/. For both sexes, there were separate CDs for the vowels /a/ and /u/ for the velar stops.

Table 6 Mean CD for each stop consonant in varying vowel context separated by gender

Sound	**Sex**	**/a/**	**/i/**	**/o/**	**/u/**	**/e/**	**Mean**	**SD**
/b/	Male	56.31	75.12	82.43	90.34	86.45	82	4.12
	Female	78.23	76.54	91.54	97.43	89.34		
/d/	Male	66.81	87.22	78.34	78.87	90.65	87	4.32
	Female	67.12	87.32	82.76	79.54	94.56		
/t/	Male	64.91	68.43	70.65	65.23	61.65	66	3.32
	Female	65.34	89.45	78.65	76.34	68.65		
/p/	Male	118.71	112.21	95.23	102.32	97.54	110	4.54
	Female	121.21	123.21	98.34	107.54	100.65		
/g/	Male	121.91	102.34	110.33	103.34	94.45	100	4.21
	Female	124.54	106.23	121.43	109.32	99.34		
/t/	Male	67.71	108.43	82.12	98.55	83.22	92	3.12
	Female	70.65	117.12	98.54	100.43	89.54		
/k/	Male	73.45	119.22	100.34	101.23	92.23	97	4.22
	Female	75.42	122.34	106.22	109.34	26.64		

Discussion

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Online ISSN: 2992-4987

Discussion on English Stops VOT Categories Produced by Hausa Native Speakers

The descriptive findings of this study indicate that the VOT value ranges for English stops vary. According to Macleod and Stoel-Gammon (2005), the voiceless stops /t/ and /p/ in English have the same VOT values with speakers of Canadian English.

There are three distinct groups of stop sounds that arise throughout the VOT continuum, according to several cross-language researches. The voicing differences are implemented differently in different languages. It was discovered that certain languages have prevoicing, lengthy voicing lag, and short lag. It has been observed that voiceless stops in languages such as Italian, Afrikaan, Spaish, and Canadian English show a brief voicing lag (Jones & Meakins, 2013; Lisker & Abramson, 1964; Stoel-Gammon, 2005). However, voiceless stops in languages such as Chinese and English have a considerable voicing lag (Lisker & Abramson, 1964). According to certain studies (Jones & Meakins, 2013; Lisker & Abramson, 1964), Thai and Gurindji Kriol are distinguished by having a brief voicing lag in their voiced pauses. According to reports, the voiced pauses in Italian, Spanish, and Turkish have prevoicing or voicing lead (Ogut et al., 2006).

In Hausa language, the voiced and voiceless stops are categorized as having a short voicing lag and a long voicing lag, respectively. As a result, Hausa's voiced stops exhibit a small voicing lag, similar to that of Thai and Gurindji Kriol (Kessinger & Blumsten, 1997). In a same vein, Hausa shares significant voicing lags with Turkish and English in their voiceless stops. Conversely, the Hausa voiceless and voiced stops are categorized as having short voicing lag and voicing lead or prevoicing, respectively. The voicing lead or prevoicing in the voiced stops of the language is comparable to those of Italian, Spanish, Thai, and Turkish. Additionally, the voiceless stops in the Hausa language are more like those in Italian, Canadian English, Afrikaan, and Spanish than they are distinct from them.

Discussion on English Stops CD Categories Produced by Hausa Native Speakers

It was discovered that the voiceless stops in the Hausa language had longer CDs than the voiced stops, and vice versa. Longer closing times are linked to voiceless stops (Zue, 1976). Alveolar plosives have a significantly shorter duration than voiced bilabial plosives, according to Crystal and House (1987).

There is a difference in Closure Duration between voiced and voiceless stops, according to several research that are presented in Section 2.2.4 of the review. Longer CDs in some languages indicate voiced stops, while shorter CDs are present in others (Vicenik, 2010). According to reports, the voiced stops in languages like English and Georgian have a brief closure duration (Docherty, 1992; Vicenik, 2010). Fitscher-Jorgesen (1954) observed that the voiceless stops in the Danish language are shorter in duration. Similar to English, Hausa features voiced plosives with shorter durations. In a similar vein, Hausa's voiceless stops last longer than those in English.

It has been discovered that the voiced stops in the Hausa language have shorter lengths than the voiceless stops. It was discovered that the duration of voiced and voiceless stops in Hausa was comparable in terms of CD.

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The voiceless phoneme /p/ was acquired by both males and females despite its absence in their native Hausa language, according to the VOT ranges produced by native Hausa speakers, which were comparatively similar to the VOT values of native English speakers.

The results also showed that the /b/ VOT levels of the male and female subjects differed significantly. This conclusion is consistent with studies by Koening (2000) and Yu et al. (2015) that found gender variations in VOT values. While Koening (2000) noted that females had comparatively greater VOTs, the current study's male participants showed relatively higher VOT values than female participants, matching the findings of Yu et al. (2015).

Conclusion and Recommendations

The purpose of this study was to investigate the acoustics of English stops made by native Hausa speakers using a single task. The design and nature of the production job used in the study may have limited the conclusions that can be made from it. It is important to acknowledge certain limitations associated with the current investigation.

Speech samples were gathered for the study in order to calculate the Voice Onset Time values and Stop Sound Closure Durations. But only the VOT values and the Closure Durations of the stops were ascertained through acoustically measuring the sounds in accordance with the standards established by the earlier researchers. To investigate more acoustic differences of English stops by Hausa native speakers, more research is needed to measure other acoustic characteristics like Voicing Terminating Time (VTT), Intra-oral Pressure (PO), Sub-glottal Pressure (PS), Oral Flow (FO), Sternothyroid Muscle (SH), and Sternohyoid Muscle (ST).

Words alone were employed in this investigation. The current study's participants may have been extremely cautious in how they articulated themselves since they might have guessed the study's goal. Future research ought to employ speeches given in natural settings, since this could contribute to a better understanding of the variations in VOT and CD in spontaneous speech.

In terms of differences, the conclusions derived from the analysis results given in the study are a little hazy. Future studies may reproduce the current study with a wider coverage of the Hausa population.

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References

Abbasi, A. M., Channa, M. A., Husain, I., & Khan, M. A. (2022). Temporal Patterns of Voice Onset Time of English-Sindhi Stops.

Abdelli-Beruh, N. B. (2004). The stop voicing contrast in French sentences: Contextual sensitivity of vowel duration, closure duration, voice onset time, stop release and closure voicing. *Phonetica*, *61*(4), 201-219.

Abdullahi, J. (2018). Cross-language perception and production of stops and fricatives among Malay and Hausa native speakers. *Unpublished PhD thesis, Universiti Putra, Malaysia*.

Alsuhaim, W. (2022). Gender Differences in the Acquisition of the VOT of English Bilabial Stops among Saudi ESL Learners. *Journal of Language and Linguistic Studies*, *18*, 100-107.

Caruso, A.J., Burton, E.K., (1987). Temporal acoustic measures of dysarthria associated with amyotrophic lateral sclerosis. Journal of Speech and Hearing Research, 30, 80–87.

Crystal, D. (2008). A Dictionary of Linguistics and Phonetics

Crystal, T. H., & House, A. S. (1988). Segmental durations in connected-speech signals: Syllabic stress. *The Journal of the Acoustical Society of America*, *83*(4), 1574-1585.

Dattalo, P. (2018). Determining sample size using fast and slow thinking. *Journal of Social Service Research*, *44*(2), 180-190.

Decker, T. N., & Carrell, T. D. (2004). *Instrumentation: An introduction for students in the speech and hearing sciences*. Psychology Press.

Docherty, G. J. (1992). *The timing of voicing in British English obstruents* (No. 9). Walter de Gruyter.

Fischer-Jørgensen, E. (1954). Acoustic analysis of stop consonants. *Le Maître Phonétique*, *32*, 42-59.

Flege, J. E., & Port, R. (1981). Cross-language phonetic interference: Arabic to English. *Language and speech*, *24*(2), 125-146.

Fuchs, S. (2005). Articulatory correlates of the voicing contrast in alveolar obstruent production in German. *ZAS papers in Linguistics*, *41*, 252-252.

Jang, M. (2022). Gender effect on the use of phonetic cues for stops in the Kyungsang dialect. *언어과학연구*, *103*, 185-206.

Jessen, M. (2001). Phonetic implementation of the distinctive auditory features [voice] and [tense] in stop consonants. *Distinctive feature theory*, *2*, 237.

Jones, C., & Meakins, F. (2013). Variation in voice onset time in stops in Gurindji Kriol: Picture naming and conversational speech. *Australian journal of linguistics*, *33*(2), 196-220.

Kent, R. & Read, C. (2002). Acoustic Analysis of Speech. 2nd Edition. University of Wisconsin-Madison. Thomson Learning.

Kessinger, R.H., Blumstein, S.E., (1997). Effects of speaking rate on voice-onset time in Thai, French, and English. *Journal of Phonetics*, 25, 143–168.

Kewley-Port, D., & Preston, M. S. (1974). Early apical stop production: A voice onset time analysis. *Journal of Phonetics*, *2*(3), 195-210.

Koenig, L. L. (2000). Laryngeal factors in voiceless consonant production in men, women, and 5-year-olds. *Journal of Speech, Language, and Hearing Research*, *43*(5), 1211-1228.

http://www.lijassed.org
Print ISSN: 2992-4979
Online ISSN: 2992-4987

Lisker, L. (1957). Closure duration and the intervocalic voiced-voiceless distinction in English. *Language*, *33*(1), 42-49.

Lisker, L. & Abramson, A. (1967). Some effects of context on voice onset time in English stops. *Language and speech*, 10, 1-28. doi:10.1177/002383096701000101.

Lisker, L., Abramson, A.S., (1964). A cross-language study of voicing in initial stops: Acoustical measurements. *Word*, 20, 384–422.

Lisker, L., Abramson, A.S., (1970). The voicing dimension: some experiments in comparative phonetics. In: Proceedings of the 6th International Congress of Phonetic Sciences, 563–567.

Lisker, L., Abramson, A.S., (1971). Distinctive features and laryngeal control. Language 47, 767–785.

Lousada, M., Jesus, L. M., & Hall, A. (2010). Temporal acoustic correlates of the voicing contrast in European Portuguese stops. *Journal of the International Phonetic Association*, *40*(3), 261-275.

Ma, J., Chen, X., Wu, Y., & Zhang, L. (2018). Effects of age and sex on voice onset time: Evidence from Mandarin voiceless stops. *Logopedics Phoniatrics Vocology*, *43*(2), 56-62.

Macleod, A.A.N., Stoel-Gammon, C. (2005). Are bilinguals different? What VOT tells us about simultaneous bilinguals. *Journal of Multilingual Communication Disorders* 3, 2, 118–127.

Naidoo, S. (2010). A re-evaluation of the Zulu implosive [6]. *South African Journal of African Languages*, *30*(1), 1-10.

O'Connor, J. (2000). Better English pronunciation. Second Edition. Cambridge University Press.

Öğüt, F., Kiliç, M. A., Engin, E. Z., & Midilli, R. (2006). Voice onset times for Turkish stop consonants. *Speech Communication*, *48*(9), 1094-1099.

Port, R. F. (1979). The influence of tempo on stop closure duration as a cue for voicing and place. *Journal of Phonetics*, *7*(1), 45-56.

Rusz, J., Tykalová, T., Novotný, M., Zogala, D., Růžička, E., & Dušek, P. (2022). Automated speech analysis in early untreated Parkinson's disease: Relation to gender and dopaminergic transporter imaging. *European journal of neurology*, *29*(1), 81-90.

Sani, M. A. Z. (2005). *Introductory Hausa Phonology*. Kano: Usman Al-Amin Publishers. Nigeria

Slis, I. H., & Cohen, A. (1969). On the complex regulating the voiced-voiceless distinction I. *Language and speech*, *12*(2), 80-102.

Smith, B. L., Hayes-Harb, R., Bruss, M., & Harker, A. (2009). Production and perception of voicing and devoicing in similar German and English word pairs by native speakers of German. *Journal of Phonetics*, *37*(3), 257-275.

Thorsen, K., & Johannessen, A. (2023). How gender matters in demanding caring for a spouse with young-onset dementia. A narrative study. *Journal of women & aging*, *35*(1), 81-97.

Umeda, N. (1977). Consonant duration in american english. *The Journal of the Acoustical Society of America*, *61*(3), 846-858.

Vicenik, C. (2010). An acoustic study of Georgian stop consonants. *Journal of the International Phonetic Association*, *40*(1), 59-92.

http://www.lijassed.org
Print ISSN: 2992-4979
Online ISSN: 2992-4987

Weismer, G. (1983). Studies of phrase-level speech timing. *The Journal of the Acoustical Society of America*, *73*(S1), S65-S66.

Whiteside, S. P., & Marshall, J. (2001). Developmental trends in voice onset time: Some evidence for sex differences. *Phonetica*, *58*(3), 196-210.

Yanagida, S., Nishizawa, N., Mizoguchi, K., Hatakeyama, H., & Fukuda, S. (2015). Voice Onset Time for the Word-Initial Voiceless Consonant/t/in Japanese Spasmodic Dysphonia—A Comparison With Normal Controls. *Journal of Voice*, *29*(4), 450-454.

Yu, V. Y., De Nil, L. F., & Pang, E. W. (2015). Effects of age, sex and syllable number on voice onset time: Evidence from children's voiceless aspirated stops. *Language and speech*, *58*(2), 152-167.

Zhang, Z. (2021). Contribution of laryngeal size to differences between male and female voice production. *The Journal of the Acoustical Society of America*, *150*(6), 4511-4521.

Zue, V. W. (1976). Acoustic characteristics of stop consonants: a controlled study.