CONSONANT SOUND ALTERNATIONS IN SPEECH: A CASE STUDY OF STUDENTS WITH CLASS III MALOCCLUSION CONDITION

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Article Info	Abstract
	The position of the tongue and teeth as the articulatory settings forms sounds during speech production. Understanding this, this study aims to identify the sound alternation outcomes most affected by changes in jaw position, namely Class III malocclusion (underbite). As participants in this study, Universitas Airlangga students are required to perform reading tasks focusing on consonant sounds in their first language, Indonesian. Qualitative research is used to analyze sound alternation, drawing on theories from Field (2004) in the Psycholinguistics study and Dardjowidjojo (2009) in the Phonetics study. Voice recordings of reading exercises using three texts were collected from the two participants. Analysis of this data showed that both individuals frequently substituted the /s/ and /z/ sounds, accounting for the majority (76.25%) of all sound changes observed. Furthermore, the study identified other sound alterations, including insertions (7.5%), deletions (12.5%), and metathesis (3.75%). These results suggest that an underbite affects the production of various sounds, not just the substitution of the sibilants /s/ and /z/. The researchers expect this study to contribute to psycholinguistic research by providing sound alternative surveys of people with Class III malocclusion.

INTRODUCTION

In producing speech, articulatory settings play an important role in shaping sounds, including the positions of the tongue and teeth (Field 2004). Due to the involvement of articulatory movements, significant changes in tooth form can also affect speech production (Oliver et al., 2023). Therefore, it can be deduced that having a misaligned tooth condition, or malocclusion, would result in how sounds are shaped. There are various cases of people having only teeth alignment problems; however, some are born with misaligned teeth because the upper and lower jaws do not meet properly. One of the misaligned-jaw cases that affects tooth position is the Class III malocclusion. Class III malocclusion, or underbite, is a condition in which the lower jaw protrudes anterior to the upper jaw (Araújo & Buschang, 2025). This position leads to an improper bite, with the bottom teeth extending further outward than the upper teeth. Compared to other cases of malocclusion, Class III malocclusion, or more commonly referred to as an underbite, has been shown to produce profound distortions in the production of both sibilant and dental sounds (Oliver et al., 2023). Its prevalence is significant, as it is highest in the Asian population (Jaradat, 2018). Given this, Asian individuals are the participants in this research.

As the focus of this study will be on difficulties in producing certain sounds, the researchers rely on psycholinguistics as the leading theory. The study of speech production in psycholinguistics was introduced by Field (2004) with a focus on the phonetic stage. According to Field (2004), models of speech production must include five stages, with the phonetic phase as the last, in which articulator control is the feature that generates speech. Apart from the vocal tract, which is the primary focus in producing sounds, articulators that approach one another also play an important role in shaping the sound. To create comprehensible words and establish communication, a combination of consonant and vowel sounds is necessary. In producing utterances, the speaker first has to understand how to generate specific sounds with the involvement of articulators in distinguishing the production of consonants and vowels.

Compared with vowels, consonants are influenced more by the restriction or obstruction of airflow due to the articulators' movement. Therefore, this study focuses on consonant sounds to identify sound alternations resulting from changes in tooth and jaw positions. Consonants are directly involved in the position of the teeth and tongue; thus, any changes in the oral cavity affect speech production. Because people with Class III malocclusion have jaw placement that affects tooth position and tongue movement, which in turn affects speech production, the targeted sounds to be examined are based on place of articulation: labiodental, dental, alveolar,

and post-alveolar. Meanwhile, regarding the manner of sound articulation, the targeted sounds include fricatives, affricates, and stop consonants.

This research would utilize phonetic theory, in addition to psycholinguistics, to identify sounds, as the variety of articulator movements shapes consonant sounds (Ladefoged & Johnson, 2011). For the study, as the respondents are Indonesian, native sounds are subject to further examination. The findings referred to Dardjowidjojo's study on Indonesian consonants. The researcher has identified targeted Indonesian consonants that are to be tested, which are /p/, /b/, /t/, /d/, /k/, /g/, /s/, /z/, /f/, /h/, /x/, /ʃ/, /tʃ/, /dʒ/, /m/, /n/, /ŋ/, /ɲ/, /l/, /w/, /y/, and flapped of /r/ sounds. Sounds targeted. The objective of this study is to identify the speech sounds produced by Universitas Airlangga students with Class III malocclusion as participants. Participants are to perform a pronunciation task and engage in a reading task using the provided words on certain consonant sounds designed by the researcher. The audio and visual recordings are analyzed further to identify alternative sounds in respondents' speech. All things considered, the researcher expects this study to provide further insights into sound alternations in the speech production of Indonesian individuals with a Class III malocclusion.

Several studies have examined the relationship between malocclusion and sound production. First is concerned on how jaw disproportions can affect in plosive, fricatives, and affricates sounds, however with focus on Class II malocclusion patient as the main objectives (Oliver et al., 2023) and a quantitative study with Class III malocclusion conditions that are showing high prevalence of speech errors based on severity of jaw disproportions (Lathrop-Marshall et al., 2022) with both focused on patients in Europe. The last is the relationship between malocclusion and speech, especially in the open-bite condition (Leavy et al., 2016). As these studies centered on different fields, this paper focuses only on the psycholinguistic aspect, specifically sound alternations in speech produced by Universitas Airlangga students with Class III malocclusion. Since this study focuses on the production of alternated sounds by people with a Class III malocclusion condition, the primary scope is psycholinguistics.

This research uses Field's (2004) theory to support the analysis. Field (2004) stated that, to produce speech, there are five stages in total, referred to as models of speech production: conceptual stage, syntactic stage, lexical stage, phonological stage, and phonetic stage. The first concerns how words are formulated in abstract form, meaning that it is the intention to vocalize certain words. The next phases, which include syntactic and lexical stages, involve selecting words or messages that fit the appropriate grammatical structure, with support from lexical entries to find words that can express the intended meaning. The lexical stage considers a factor, too, for example, how words will have connected meaning when they are set in sentences.

Meanwhile, in the last two stages, both the phonological and the phonetic stages involve speech production. The phonological stage emphasizes the conversion of information gathered at the lexical level into speech. The last concerns the actual vocalization of intended words. In the phonetic stage, the lips, tongue, teeth, and position of the alveolar ridge all function as articulators that collaborate to shape the sounds that the speaker produces. Based on Field's (2004) theory, as described in the last point, this phonetic stage serves as the primary foundation for this study.

Speech production is closely related to the sounds speakers produce and is intertwined with the field of phonetics. The researchers apply theories of English and Indonesian phonetics to determine which sounds occur in both word contexts. The difficulties in producing sounds for people with Class III malocclusion depend on the set of tongue movements and the position of the teeth; targeted sounds are consonants, which are divided into place and manner of articulation.

According to Dardjowidjojo (2009), places of articulation for tongue and teeth gestures are labiodental, dental, alveolar, and post-alveolar. Labiodental sounds, such as/f/ and /v/, are produced by raising the lower lip until it nearly touches the upper front teeth, creating a small space for friction. To produce alveolar sounds, the tip of the tongue has to touch the alveolar ridge to create /t/, /d/, /n/, /s/, /z/, /l/, and /r/ sounds. The last is post-alveolar sounds, such as /ʃ/, /ʒ/, /tʃ/, and /dʒ/, which are produced by raising the tongue blade to the back of the alveolar ridge.

All aforementioned consonant sounds are also classified based on manner of articulation: stop, fricative, affricate, and approximant sounds. For /t/ and /d/, they are considered stop sounds, meaning that to produce these sounds, the airstream has to be blocked or stopped for a short period of time. Furthermore, /f/, /v/, /s/, /z/, /ʃ/, and /ʒ/ are grouped as fricative sounds. Fricative sounds mean the airstream is partially obstructed, and airflow is produced through the narrow constriction of articulators. Another is affricate sounds, which are the combination of a stop and a fricative produced sequentially, resulting in/tʃ/ and /dʒ/. The last is approximant, sounds that are created through motion where two articulators are in close contact to one another without significantly narrowing the vocal tract to produce an unstable airstream. Examples of approximant sounds are /l/ and /r/. Given its emphasis on sound alternations in speech produced by individuals with an underbite, the primary objective of this study is to comprehend the reasons for sound alternations occurring during speech and identify the specific sounds to which they are alternated.

METHOD

In this study, the researchers focus on a qualitative approach. According to Dawson (2007), qualitative research explores the experiences and activities of targeted samples through techniques including interviews. Furthermore, qualitative research focuses on concepts and is not inclined to numerical data; thus, the number of respondents can be overlooked. In accordance with the qualitative approach, this research employs a case study design. It is supported by Miles and Huberman (2020), who argue that a case study is one of the research designs that analyzes a phenomenon through the study of a single case or bounded context. Miles and Huberman (2020) also believed that a case study should focus on an individual, a group, or a community, as long as they are undergoing the same phenomenon. For this research, a case study could identify alternative sounds produced by Universitas Airlangga students with Class III malocclusion.

Participants

As data sources, results from the reading task serve as the primary data for this study. The researchers employ observation and interviews as data-collection techniques, along with audio-visual recordings using a tape recorder and a camera, photographs of participants with consent, and field notes taken during the observation to add detail. The chosen participants in this study are Universitas Airlangga students from the English Department, batch 2020, with Class III malocclusion, as evidenced by a protruding lower jaw, resulting in the bottom teeth being positioned forward.

Figure 1: Male Student's Class III Malocclusion Condition

Figure 2: Male Student's Class III Malocclusion Condition

Figure 3: Female Students's Class III Malocclusion

Figure 4. Female Student's Class III Malocclusion

As neither participant provides medical records to confirm their Class III malocclusion, the justification of their conditions relies on the resemblance of their conditions to Class III malocclusion and their patients' picture diagnoses by Araújo and Buschang (2025).

Instruments

To investigate sound alternations in speech production, the researcher conducted a reading task in which participants read provided texts. For this study, three texts were selected to provide comprehensive insights into the occurrence of sound alternations across various

scenarios. Three Indonesian texts were given to the participants as an instrument to be read during the voice recording. The decision to use Indonesian stems from the fact that both participants are native speakers. This choice aimed to prevent potential sound alterations resulting from participants' unfamiliarity with producing sounds in a different language. The first text to be read is a narrative comprising 568 words, while the second text mirrors this structure with 564 words. The choice of narrative text was deliberate, aiming to use simple, everyday language to prevent participants from becoming bored during the reading task. The use of narrative texts is also intended to minimize the possibility of 28 sound alternations, as participants have limited knowledge of producing these sounds, as the texts include words commonly used in daily life. The choice of narrative text is also supported by Owen (2016).

From the moment of birth, children are immersed in the world of storybooks, cultivating a sense of familiarity that persists into their later years. The deliberate choice of narrative texts is driven by the understanding that early exposure to such texts lays the foundation for seamless reading development as children mature. The realization is that engaging with narrative texts plays a pivotal role in determining the fluency of participants' reading task sessions, as they are familiar with story texts. To diversify the study, the third text, sourced from CNN Indonesia (2024), is a 245-word news article. This decision was made to introduce new variation and to observe sound alternations with a shorter text. All instrument texts were designed and chosen by the researcher to ensure the inclusion of all Indonesian consonant sounds.

Procedures

As the study revolves around a case study of target respondents, the data collection techniques used are interviews and observation. An interview is a mandatory requirement to extract information from respondents (Litosseliti, 2010). For this occasion, the information consists of the results of the provided pronunciation and reading tasks. Since the data will be analyzed further, a tape recorder and a video camera are needed for the interview. The process includes pronunciation tasks in which respondents are requested to pronounce targeted sounds. Reading task is required as well to assess participants' capability in producing certain consonant sounds. Alongside the interview process, observation is necessary to complete the analysis. Observations range from listening, questioning, and communicating to interacting with respondents (Miles & Huberman, 2020). To finalize the observation process, data collection tools such as a camera and a tape recorder are extensively used. Moreover, to record details during and after the observation, the researchers would use field notes. With consent, the

researcher is to provide pictures of respondents' conditions to introduce Class III malocclusion to readers and enhance the credibility of the research.

Data Analysis

Because the research is qualitative and focuses on the psycholinguistic field, the data analysis technique is descriptive. After gathering data through field audio-visual recordings, the researcher is to undertake analysis, along with secondary data, first to assess which alternative sounds occur during speech. The analysis, following the identification of results, involves examining all sounds, classifying them into four categories: substitution, insertion, deletion, and metathesis, as discussed by Davenport and Hannahs (2020). These findings, detailing the types of 30 sound alternations during speech production produced by Universitas Airlangga students with Class III malocclusion condition, answer the first research question. Moreover, the researchers analyze the most prevalent sound alternations and investigate the reasons behind their occurrence to address the second research question. Following the discussion, a conclusion is drawn from the results and analysis.

FINDINGS AND DISCUSSION

The sound alternations are presented in the following table:

Table 1. Result of Reading Task Text 1 by Male Student

Timestamp	Uttered	Intended	Meaning
00:33	[bər.ˈla.lurt ˈla.rut]	[bər.ˈla.rut ˈla.rut]	berlarut-larut
00:41	[bər.ˈla.lir ˈla.ri]	[bər.ˈla.ri ˈla.ri]	berlari-lari
00:53	[kə.ka.wa.ˈti.ran]	[kə.ħa.wa.ˈti.ran]	kekhawatiran
00:58	[ˈa.kir ˈa.kir]	[ˈa.ħir ˈa.ħir]	akhir-akhir
01:24	[d͡ʒa.ˈwa.ban]	[d͡ʒau.ˈpan]	jawaban
02:21	[ˈa.kir ˈa.kir]	[a.ħir ˈa.ħir]	akhir-akhir
02:26	[ba.ˈsar]	[ba.ˈzar]	bazar
02:33	[ˈgun.dah ˈgu.na.la]	[ˈgun.dah ˈgu.la.na]	gundah-gulana
02:47	[ba.ˈsar]	[ba.ˈzar]	bazar
02:57	[ba.ˈsar]	[ba.ˈzar]	bazar
03:14	[ba.ˈsar]	[ba.ˈzar]	bazar
03:20	[mən.ˈtʃa.ri]	[mən.t͡ʃri]	mencari
03:27	[ba.ˈsar]	[ba.ˈzar]	bazar
03:32	[ti.dak]	[ti.tak]	tidak
03:37	[aŋ.ga.ran]	[a.naŋ.ga.ran]	anggaran
04:45	[di.si.ap.kan]	[di.zi.ap.kan]	disiapkan

Table 2. Result of Reading Task Text 2 by Male Student

Timestamp	Uttered	Intended	Meaning
00:11	[brɐ.ˈsil]	[brɐ.ˈzil]	Brazil
00:22	[bər.ˈtaɲ ˈta.ɲa]	[bər.ˈta.ɲa ˈta.ɲa]	bertanya-tanya
00:27	[kə.ku͡a.ta.ˈrian]	[kə.ħa.wa.ti.ˈran]	kekhawatiran
00:37	[mə.ɲa.la.kan]	[mə.ɲa.lah.kan]	menyalahkan
00:44	[brɐ.ˈsil]	[brɐ.ˈzil]	Brazil

Timestamp	Uttered	Intended	Meaning
01:31	[brɐ.'sil]	[brɐ.'zil]	Brazil
01:47	[brɐ.'sil]	[brɐ.'zil]	Brazil
02:31	[mə.ma.rai.ku]	[mə.ma.ra.hi.ku]	memarahiku
02:45	[mə.ŋa.wa.tir.kan]	[məŋ.ħa.wa.tir.kan]	mengkhawatirkan
03:17	[an.'di.sa]	[an.'di.za]	Andiza
03:23	[an.'di.sa]	[an.'di.za]	Andiza
03:24	['ta?di]	['ta.di]	tadi
03:26	[brɐ.'sil]	[brɐ.'zil]	Brazil
03:44	[diɹ.'sa.na]	[di.'sa.na]	di sana
03:47	[a.'fan.sa]	[a.'fan.za]	Avanza
04:21	[brɐ.'sil]	[brɐ.'zil]	Vrazil
04:28	[brɐ.'sil]	[brɐ.'zil]	Brazil
04:32	[brɐ.'sil]	[brɐ.'zil]	Brazil
04"57	[an.'di.sa]	[an.'di.za]	Andiza

Table 3. Result of Reading Task Text 3 by Male Student

Timestamp	Uttered	Intended	Meaning
00:09	['ga.sa]	['ga.za]	Gaza
00:18	[ga.sa]	[ga.za]	Gaza
01:41	[mu.'ba.sir]	[mu.'ba.zir]	mubazir
01:42	['fi.sal]	['fis.kal]	fiskal
01:50	[sə.'ta.ʊn]	[sə.'ta.ħʊn]	setahun
01:51	['t͡ra.kir]	[tər'a.ħir]	terakhir
02:36	[sə.'bə.zar]	[sə.'bə.sar]	sebesar

Substitution

Based on the data presented, the dominant sound alternation that emerges during the reading task is substitution. As performed by the male student in the first text (refer to Appendix), the participant substituted the [z] sound provided in the text with the [s] sound five times for the same word, that is, *bazar*.

Uttered	**Intended**	**Meaning**
[ba.'sar]	[ba.'zar]	bazar

The substitution of the [z] sound for the [s] consonant sound happened as well in the second text (refer to Appendix), which is more frequent than the first text, where the alternation occurred eight times in the word *brazil,* three times in the word *andiza*, and once in the word *Avanza*.

Uttered	**Intended**	**Meaning**
[brɐ.'sil]	[brɐ.'zil]	Brazil
[an.'di.sa]	[an.'di.za]	Andiza
[a.'fan.sa]	[a.'fan.za]	Avanza

Substitution of the [z] sound, which became the [s] sound, appeared twice in the third text of *Gaza* word and once in the *mubazir* word (refer to the Appendix).

Uttered	**Intended**	**Meaning**
['ga.sa]	['ga.za]	Gaza
[mu.'ba.sir]	[mu.'ba.zir]	mubazir

The reverse substitution of [s] to [z] sound occurs twice: once during the reading task session for the first text and again for the third text (refer to Appendix).

Text	Uttered	Intended	Meaning
1	[di.si.ap.kan]	[di.zi.ap.kan]	disiapkan
3	[sə.ˈbə.zar]	[sə.ˈbə.sar]	sebesar

Other than the alternation with the involvement of [s] and [z] sounds, there were substitutions for the [ħ] sound that changed to the [k] sound. The substitution emerged in the first text (refer to Appendix) once in kekhawatiran and twice in akhir-akhir.

Uttered	Intended	Meaning
[kə.ka.wa.ti.ran]	[kə.ħa.wa.ti.ran]	kekhawatiran
[a.kir ˈa.kir]	[a.ħir ˈa.ħir]	akhir-akhir

Substitution of [ħ] sound can be found in the second text for one time (refer to the Appendix) within different word as the first text, that is *kekhawatiran*; however, with different uttered result that also involved in the substitution of [w] sound that became the diphthong of [u͡a] sound and addition with metathesis which will be discussed on the following categories.

Uttered	Intended	Meaning
[kə.ku͡a.ta.rian]	[kə.ħa.wa.ti.ran]	Kekhawatiran

Substitutions that only appeared for once are within the alternation of [w], [b], and [d] sounds, all within the reading task for text one performed by a male student.

Sound Uttered	Uttered	Sound Intended	Intended	Meaning
[u͡a]	[kə.ku͡a.ta.rian]	[w]	[kə.ħa.wa.ti.ran]	kekhawatiran
[u]	[d͡ʒau.pan]	[w]	[d͡ʒa.ˈwa.ban]	jawaban
[p]	[d͡ʒau.pan]	[b]	[d͡ʒa.ˈwa.ban]	jawaban
[t]	[ti.tak]	[d]	[ti.dak]	tidak

During the reading task, a prevalent pattern observed among participants was the occurrence of substitution, particularly in the production of sounds with the syllable [z]. This phenomenon was notably pronounced at the initial and middle positions of syllables, particularly among male students. The [z] voiced sound was consistently replaced by the voiceless [s] sound in numerous instances. Both sounds are characterized by a narrowing of the gap between the tongue and the alveolar ridge, but they differ in the acoustic features produced—[s] is associated with a hissing noise, while [z] is characterized by a buzzing noise due to vocal cord vibration. The rationale behind this substitution seems to be rooted in the relative ease of articulating [s] compared to [z]. Unlike [z], [s] does not involve vocal cord voicing or vibration, making it a simpler sound to produce. This observation becomes particularly significant when [s] is sandwiched between vowel sounds, where the substitution tendency is most noticeable.

Beyond the realm of [z] sounds, the second most prominent substitution observed during the reading task involved the replacement of [ħ] with [k]. While [ħ] is a consonant listed in the Indonesian linguistic dictionary by Dardjowidjojo (2009), male participants often struggled to produce this sound accurately. This challenge might be attributed to the unique nature of [ħ] as a pharyngeal consonant, a feature not commonly encountered in the Indonesian phonetic repertoire. The unfamiliarity with such pharyngeal sounds may be linked to their limited use in Indonesian and to the potential influence of Arabic consonants, which may not be commonly adopted. Consequently, the participants tended to substitute [ħ] with the more familiar [k] sound.

The phenomenon of substitution extended beyond these specific instances, encompassing other consonant sounds such as [w], [b], and [t]. Interestingly, these substitutions were influenced by the position of the jaw during sound production. Jaw position plays a crucial role in shaping the oral cavity and, consequently, in the articulation of speech sounds. In the case of [w], [b], and [t], participants showed variations in pronunciation, suggesting that jaw position influenced their articulation. This observation underscores the intricate relationship between oral anatomy and speech production, emphasizing that the physical configuration of the oral cavity, including the jaw's position, can impact the accurate articulation of specific consonant sounds.

One plausible explanation for the prevalence of substitutions lies in the intricate interplay of linguistic, physiological, and cognitive factors. Linguistically, the presence of specific sounds in a language and their frequency of use can shape an individual's phonetic repertoire. If certain sounds are less familiar or less regularly encountered in a language, speakers may have difficulty accurately producing them. It is evident in the case of the pharyngeal consonant [ħ], which, although present in the linguistic dictionary, may not be frequently employed in everyday speech, leading to a lack of familiarity among speakers.

Physiologically, the unique characteristics of speech sounds, such as voicing and place of articulation, can influence the ease with which they are produced. The substitution of [s] for [z], for instance, reflects the preference for sounds that require less intricate coordination, as [s] does not involve the added complexity of vocal cord vibration. Similarly, the challenge in producing [ħ] may stem from the unfamiliarity with pharyngeal articulations, which can be less common in specific linguistic contexts. Cognitively, the mental representations of sounds in an individual's linguistic system play a crucial role in accurate articulation. If a speaker's mental representation of a sound is not well-established or if perceptual biases influence it, the likelihood of substitution increases. It could explain why participants consistently substituted

[s] for [z] in specific phonetic contexts, as the mental representation of [s] appeared more accessible or well-established than that of [z].

The observed pattern of substitution during the reading task, encompassing the replacement of [z] with [s] and [ħ] with [k], underscores the intricate dynamics of speech production. The interplay of linguistic, physiological, and cognitive factors contributes to the observed variations, highlighting the nuanced relationship between language, anatomy, and cognitive processes. Understanding these patterns provides valuable insights into the complexities of speech production and can inform targeted interventions to improve phonetic accuracy for individuals facing challenges with specific sound substitutions.

Insertion

The second type of sound alternation involves the insertion of sounds into existing words. In this instance, the alternation occurred only in the case of the male student. There are several instances of the male student inserting sounds for words during the reading task. For the first text, the male student had two different examples with sound insertions during speech production. The word *berlarut-larut* involves the insertion of the [l] sound at the beginning of the first syllable and a metathesis phenomenon, which will be discussed in its dedicated sub-section. The second alternation is the insertion of the [r] sound in *berlari-lari* as an onset syllable. Insertion in the reading task of the male student emerged in the second text as well (refer to *table 4*), showcasing variations of the vowel insertion, the glottal stop [ʔ] in tadi, and the addition of [r] in *di sana* words. The final insertion is the addition of the vowel [a] in the word *anggaran* in the third text.

An illustration of phonetically conditioned alternation is evident in the transformation of *berlarut-larut* to [bər.la.lurt.la.rut], where the insertion of /l/ occurs. This additional [l] sound emerges after the [la] sound. Given the prior mention of challenges faced by individuals with Class III malocclusion or underbite, who may struggle with tongue movement to the alveolar ridge, the inserted sound might result from efforts to produce an alveolar flap sound or /r/ consonant swiftly after the /l/ consonant. It is the exact reason for the additional /l/ in the word *berlari-lari* that is pronounced as [bər.la.lir.la.ri]. After saying the sound [la], to have the tongue touch the alveolar ridge could be quite an effort to do, especially when the speaker with a Class III malocclusion condition has to speak for a long run. Therefore, instead of producing the [r]sound, the speaker opts for the same sound as the preceding consonant, that is, the [l] sound. In addition to the additional [l] sound, there is also a noticeable insertion of the [r] sound at the

end of a syllable, which acts as the metathesis alternation of the supposed to be [r]sound after the sound [la].

The insertion of the [r] sound also exists in the words *berlari-lari* and *di sana*. The alveolar flap sound is added at the end of the syllable after the vowel /i/. For the first example, the explanation is linked to the reason why the speaker chooses to add the [r] sound. The male student pronounced the word *berlari-lari* as [bər.la.lir.la.ri]. The intended pronunciation of the [r] sound as the onset syllable is instead realized at the end of the syllable, suggesting a potential effort by the speaker to produce this sound correctly. However, given that the [l] sound already serves as the onset syllable, the speaker adjusts by placing the /r/ at the syllable's end, aiming to achieve the correct phonetic outcome.

Nevertheless, this rationale does not align with the insertion of the [r] sound in the word *di sana*. In this instance, the speaker, in articulating the [d] and [s] sounds, naturally positions the tongue back to the alveolar ridge. Both sounds are alveolar in nature, thus minimizing the difficulty of transitioning swiftly between them. The additional /r/ may be a mistake on the speaker's part, since this alternation occurred only once. This logic can be applied to the explanation of the additional glottal stop in the word tidak after the [i] vowel.

To enhance clarity, the researcher facilitates references to identify sound alternations in the instrument texts. The male participant is denoted as "M"; the female participants are denoted as "F". The number within parentheses indicates the specific text, with the letter "T" following, used to refer to the title, or the subsequent number specifying the relevant paragraph in the text.

Table 4. Occurrence Samples of Insertion

Reference	Sound Inserted	Uttered	Intended	Meaning
M(1).2	[l]	[bər.'la.lurt 'la.rut]	[bər.'la.rut 'la.rut]	Berlarut-larut
M(1).2	[r]	[bər.la.lir.la.ri]	[bər.la.ri.la.ri]	Berlari-lari
M(2).1	[a]	[kə.kua.ta.rian]	[kə.ħa.wa.ti.ran]	Kekhawatiran
M(2).7	[ʔ]	['taʔdi]	['ta.di]	Tadi
M(2).8	[r]	[dir.'sa.na]	[di.'sa.na]	Di sana
M(3).3	[a]	[a.naŋ.ga.ran]	[aŋ.ga.ran]	Anggaran

Deletion

Omitting or deleting sound is the third sound alternation that occurred in both the male and female students. In the first text, deletion is evident for both vowel and consonant sounds. The male student alone deleted the [a] vowel sound in *jawaban* and *mencari*. In the second text (refer to *table 5*), both the male and female students demonstrated deletion alternations. The male student showed a tendency to omit the consonant /h/ when it appears between vowels; for example, [mə.ɲa.la.kan] comes from the word *menyalahkan*. Since changes do not influence

the /h/ consonant in jaw and tongue positioning, it can be inferred that this alternation is a strategic choice often employed by individuals to execute speech production in the long run. The removal of consonant /ħ/ and vowels such as /a/, /e/, and /ə/ is not directly linked to the malocclusion condition but rather serves the purpose of facilitating articulation. The only deletion that has connection with the condition is executed by the female participant by pronouncing the word *sedikit* to ['si.kit] with the same purpose as the others. By removing the [d] sound, there is little effort to have the tongue curl back to touch the alveolar sound and produce the aforementioned sound. The male participant omitted the sound [a] in *bertanya-tanya*, the [h] sound in *menyalahkan* and *memarahiku*, and omitted the [ħ] sound in the word *mengkhawatirkan*. The female participant exhibited deletion in the word *sedikit* involving [ə] and [d] sounds. In the third text (refer to *table 5*), the deletion occurred with the male student omitting sounds like [k], [h], and [ə]. The consonant is the onset of the syllable, while the schwa sound is at the end of the syllable.

Table 5. Occurrence Sample of Deletion

Reference	Sound Inserted	Uttered	Intended	Meaning
M(1).3	[a]	[dʒau.ˈpan]	[dʒa.ˈwa.ban]	Jawaban
M(1).4	[a]	[mən.tʃri]	[mən.ˈtʃa.ri]	Mencari
M(2).1	[a]	[bər.ˈtaɲ'ta.ɲa]	[bər.ˈta.ɲa'ta.ɲa]	Bertanya-tanya
M(2).1	[h]	[mə.ɲa.la.kan]	[mə.ɲa.lah.kan]	Menyalahkan
M(2).5	[h]	[mə.ma.raku]	[mə.ma.ra.hi.ku]	Memarahiku
M(2).5	[h]	[mə.ŋa.wa.tir.kan]	[məŋ.ħa.wa.tir.kan]	Mengkhawatirkan
F(2).8	[ə]	['si.kit]	['sə.di.kit]	Sedikit
F(2).8	[d]	['si.kit]	['sə.di.kit]	Sedikit
M(3).4	[k]	['fis.al]	['fis.kal]	Fiskal
M(3).4	[h]	[sə.ta.ʊn]	[sə.ta.hʊn]	Setahun
M(3).4	[ə]	[tra.kir]	[tə.ra.ħir]	Terakhir

Metathesis

Metathesis, where sounds 'positions are swapped, occurred three times in the male student's first text for the words *berlarut-larut, berlari-lari*, and *kekhawatiran* in the third text (refer to *table 6*). The first instance involves the word berlarut-larut, where the sounds [rut] are swapped, and an additional [l] is inserted, forming the [lurt] sound. There is a possibility that metathesis could be influenced by the malocclusion condition. A further instance of metathesis influenced by malocclusion is observed in the word *berlari-lari* intended as [bər.la.ri.la.ri], but transformed into [bər.la.lir.la.ri]. Here, the [ri] sound undergoes metathesis alternation to [ir] sound, accompanied by the insertion of /l/ as the onset syllable. This showcases how malocclusion conditions may contribute to the rearrangement of sounds in spoken language, emphasizing the dynamic impact of oral anatomical variations on phonetic patterns. As

discussed before, people with Class III malocclusion have restricted jaw movement when producing sounds involving tongue motion, so the speaker might have to resort to the easiest way to deliver speech for an extended period. The sounds [r] and [t] sounds in proximity, as demonstrated in *berlarut-larut*, require rapid tongue movements to both the upper teeth and alveolar ridge, which could potentially lead to difficulty in articulation due to the misalignment of the teeth and jaw in individuals with malocclusion.

Table 6. Occurrence Sample of Metathesis

Reference	Uttered	Intended	Meaning
M(1).2	[bər.la.lurt.la.rut]	[bər.la.rut.la.rut]	Berlarut-larut
M(1).2	[bər.la.lir.la.ri]	[bər.la.ri.la.ri	Berlari-lari
M(2).1	[kə.ku͡ a.ta.rian]	[kə.ħa.wa.ti.ran]	Kekhawatiran

CONCLUSION

Supported by Field's (2004) psycholinguistic theory and Davenport's (2020) phonetics study, which explore the influence of articulatory structures on sound production, this study provides evidence that changes in jaw and tooth positioning have a notable effect on sound production. Class III malocclusion condition, characterized by an underbite jaw, has visible misalignment of the bottom teeth and a protruding lower jaw. Through a reading task encompassing three texts, SS with the full Indonesian consonant repertoire available within the instruments, both male and female participants demonstrated various sound alternations, showcasing both similarities and differences. The predominant sound alternations observed involve the substitution of alveolar fricative sounds, specifically for the replacement of [z] with [s] sound and [s]with [θ] sound. In addition to the findings from previous studies, this research identifies other sound alternations that extend beyond mere substitutions. The analysis delves into cases of insertion, deletion, and metathesis, examining how anatomical adaptations contribute to the manifestation of sound alternations.

Considering that this study exclusively focuses on a case study of sound production and analyzes sound alternations produced by only Universitas Airlangga students with Class III malocclusion within the scope of psycholinguistics, it is suggested that the participant pool be expanded and that additional instruments be incorporated for future researchers. The inclusion of a more diverse group of participants from outside Universitas Airlangga would offer a broader perspective, enabling a more comprehensive understanding of how Class III malocclusion affects sound articulation. The participants suggested a range of patients with medical records, preferably to justify and document their malocclusion. In addition to considering including more participants, it is recommended that future researchers quantify the

specific sounds incorporated into the instruments. This approach aims to capture a more precise understanding of sound alterations influenced by jaw conditions rather than other factors.

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