International Journal of Linguistics and Translation Studies
Volume 5, Issue 1, 2024
Homepage: http://ijlts.org/index.php/ijlts/index
DOI: https://doi.org/10.36892/ijlts.v5i1.409

The Phonetic Realization of Obstruent Clusters in Najdi Arabic: An Exploratory Study

Rana Alsabhan (corresponding author)
University of Reading, United Kingdom, Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia
rmalsabhan@pnu.edu.sa

Jane Setter
Department of English Language and Applied Linguistics, University of Reading, United Kingdom.
j.e.setter@reading.ac.uk

How to cite:
Alsabhan, R. & Setter, J (2024). *The Phonetic Realization of Obstruent Clusters in Najdi Arabic: An* Exploratory Study. *International Journal of Linguistics and Translation Studies* 5(1).48-68.
https://doi.org/10.36892/ijlts.v5i1.409

ARTICLE HISTORY

Received: 28/10/2023

Accepted: 20/12/2023

KEYWORDS

Najdi Arabic, consonant cluster, Arabic dialect, obstruents, vowel deletion

Abstract

This study provides an acoustic analysis of the realization of the surface word-initial obstruent clusters that resulted from the deletion of short vowels in Najdi Arabic. While past studies discussed the syllable structure of Najdi Arabic and affirmed the permissibility of initial consonant clusters, most of these studies lack acoustic analyses that attest the occurrence of initial consonant clusters and left much uncertainty about the allowed and disallowed segments in the clusters. The aim of the present research is to address this gap in the literature by conducting an acoustic analysis that examined the types and patterns of the allowed obstruent clusters in Najdi Arabic dialect. Two methods were implemented to collect the data: informal interview and a reading task. The stimuli represented the four types of obstruent clusters: fricative-fricative, fricative-plosive, plosive-fricative, and plosive-plosive. Fourteen Najdi Arabic native speakers (7 males, 7 females) were recruited. The findings of this study affirmed the presence of the four types of the obstruent clusters and provided a description of their patterns in Najdi Arabic. This finding enhances our understanding of the phonology of Najdi Arabic and contributes to the wide-ranging context of Arabic dialectology with regards to phonotactics and syllable structure.

1. INTRODUCTION

Arabic dialects differ from Standard Arabic and from each other in their phonetic, phonological, syntactic, and lexical systems (Zaidan & Callison-Burch, 2014). Arabic dialects are mainly used in a spoken form for day-to-day interactions, whereas Standard Arabic is the official written form that is taught at schools and is used for formal settings, such as the news and religious ceremonies. Each Arabic dialect represents a geographical region (Alsudais et al., 2022). Saudi Arabia, for example, has broadly four main dialects for each region: Najdi Arabic, spoken in the middle region; Hijazi Arabic, spoken in the western region; Eastern Arabic, spoken in the eastern region; and Southern Arabic, spoken in the southwestern region (Prochaska, 1988).

From a phonological perspective, Saudi dialects exhibit variations with regard to syllable structure (Prochaska, 1988). Some dialects follow Standard Arabic phonotactics in disallowing words to start with initial clusters, such as Hijazi Arabic (Alfaifi, 2019) while other dialects allow words to start with initial clusters, such as Najdi Arabic (Abboud, 1979; Alghmaiz, 2013; Alqahtani, 2014; Ingham, 1994). These word-initial consonant clusters are surface sequence of two consonants, resulting from a post-lexical process characterised of the deletion of a short vowel in unstressed open syllables (Ingham, 1994). Examples from Najdi Arabic are provided in (1). All examples are glossed in IPA for ease of use by linguists.

(1)

Underlying form	Surface form	Gloss
/xuʃuːm/	/xʃuːm/	noses
/turaːb/	/traːb/	soil
/bagarah/	/bgarah/	cow

While past literature in Najdi Arabic agrees on the occurrence of the initial consonant clusters, little attention was given to the phonetic validation of vowel deletion, which in turn lead to the formation of these consonant clusters. Broadly speaking, the existing literature devotes a significant emphasis on analysing and explaining consonant clusters that inherently occur within the phonotactic structures of languages, whereas less attention has been given to exploring surface consonant clusters. This aspect of cluster formation, particularly in languages where initial clusters are typically disallowed, such as the case in Arabic dialects, represents a compelling dimension of research. Therefore, it is the purpose of this paper to provide an initial description of a specific category of surface clusters, namely obstruent clusters, as these clusters are infrequent cross-linguistically (Morelli, 1999).

The purpose of this study can be achieved by fulfilling two objectives; firstly, to phonetically explore the occurrence of obstruent clusters, and secondly, to explore the types and patterns of the allowed clusters. This study selects Najdi Arabic as the primary focus for investigation due to its rich obstruent sets involving uvular, pharyngeal, and pharyngealized obstruents, representing various voicing features as well as diverse manner and place of articulation features (Sabir & Alsaeed, 2014). Najdi Arabic has preserved the phonetic realization of the majority of these obstruents (Ingham, 1994), thereby allowing for a broader analysis. The present exploratory research is a foundational step in analysing preliminary data about initial obstruent clusters allowing for generation of hypothesis to investigate further (Roettger, 2019). This research employed acoustical analysis to verify the occurrence of the obstruent clusters relying on objective measurements to address the following research questions:

1. Does Najdi Arabic allow all four types of word-initial obstruent clusters?
2. What are the phonotactic patterns of word-initial obstruent clusters in Najdi Arabic?
3. Do word-initial obstruent clusters in Najdi Arabic correspond to the coda obstruent clusters found in Standard Arabic?

1.1.Obstruent Clusters

Consonant clusters can be defined as "a sequence of speech sounds not interrupted by a syllable nucleus nor, of course, by a pause" (Vennemann, 2012, p. 12). Obstruent clusters, a particular subset of consonant clusters, consist of plosives and fricatives organized into four logical ways: fricative-fricative (FF), e.g., the Italian /sf/, fricative-plosive (FP), e.g., English /st/, plosive-fricative (PF), e.g., Paipai /pχ/, and plosive-plosive (PP), e.g., Georgian /tp^h/. Morelli (1999) conducted a cross-linguistic study on obstruent clusters in word-initial position in 25 languages, belonging to different language families and found that obstruent clusters are attested in six possible ways, whereby each type occurs in isolation or accompanied by other types, as shown in Table 1. Based on this typology, Morelli inferred several implicational universals. Firstly, when a language allows a single type of obstruent clusters, it is the FP cluster. Secondly, the FP cluster is also present with any other type or combination of obstruent cluster types. The presence of PP clusters implies the presence of PF clusters, and the presence of FF clusters implies the presence of FP and PF clusters.

Table 1

The Typology of the Obstruent Clusters

	FF	FP	PF	PP	Language
Type 1		√			English
Type 2	√	√			Dutch
Type 3		√	√		Wichita
Type 4	√	√	√		Paipai
Type 5		√	√	√	Attic Greek
Type 6	√	√	√	√	Georgian

Note. F = fricative, P = plosive.

In Standard Arabic, it is observed that obstruent clusters, including all four types can occur in only word final position (Al Tamimi & Al Shboul, 2013). An example for each obstruent cluster type is provided in 2. Al Tamimi and Al Shboul (2013) analysed dictionary based CVCC words phonemically and identified 118 patterns of final obstruent clusters. These obstruent clusters inherently constitute phonotactically underlying permissible coda consonant clusters within the language.

(2)	Type	Example	Gloss
	FF	ħifðˤ	keeping
	FP	ʕaðb	sweet
	PF	nabð	rejection
	PP	kabt	suppression

Consonant clusters may rise within a language intrinsically or because of some morphological and phonological mechanisms. Among these processes, one of the commonest phonological processes is vowel deletion (Vennemann, 2012). In the next section, the rise of these initial consonant clusters is discussed.

1.2.The Formation of New Consonant Clusters

The phenomenon of high vowel deletion is a common phonological process found across languages (Hirayama, 2009). When vowels in medial positions are deleted, surface consonant clusters rise regardless of the phonotactics of the language. For example, Japanese syllable structure does not allow initial consonant clusters, yet when high vowels i and u occur between two voiceless consonants, these vowels are deleted, resulting in surface initial clusters (Ogasawara, 2013), examples are provided in (3).

(3)	Underlying Form	Surface Form	Gloss
	/suteki/	/steki/	'nice'
	/ɑʃita/	/ɑʃta/	'tomorrow'

The literature delivers experimental ways that confirm that kind of deletion which creates initial clusters. Whang (2018) acoustically analysed 160 native Japanese words produced by 22 Japanese speakers (gender-balanced). In this analysis, the waveform and spectrogram of each speaker were examined to measure the centre of gravity of fricatives and duration of C1 burst/friction noise. Vowels were coded as present when a phonation accompanied by formant structures between C1 and C2 were visible. Vowels were coded as absent when there was neither phonation nor formant structures between C1 and C2. Results show that Japanese high vowel can yield complete deletion.

The phonological factors that affect the deletion process include both vowel quality and consonantal contexts. Across languages, high short vowels are considered the best candidates for the deletion process when occurring in unstressed syllables, such as Greek (Dauer, 1980) and Spanish (Delforge, 2008). The effect of the flanking consonants was also attested. For example, in Japanese, the manner of articulation of the flanking obstruents has a major effect whereby deletion/devoicing rates between two fricatives or between an affricate and a fricative can reach 60%, whereas, when plosives surround high vowels or just precede them the rate raises to 100% (Fujimoto, 2015).

The phonotactics of these surface consonant clusters may vary; some could be lexically legal, which means they correspond to the native lexical clusters already exist in the language, others are illegal. For example, in English, the surface cluster /sp/ in *support* is a legal and frequent cluster inherently found in many words such as *speak* and *spy*. On the other hand, the surface cluster /pt/ in *potato* is lexically illegal in English. However, regardless of their legality, both clusters surface in fast speech (Davidson, 2006).

1.3.Najdi Arabic

Najdi Arabic (hereafter, NA) is a dialect spoken in Najd (an area located in central Saudi Arabia). The phonemic inventory of NA retains most of the sounds present in Standard Arabic, with differences arising from certain phonetic features. Overall, NA has 23 obstruents, listed in Table 2. In contrast to SA, the vowel inventory of NA includes eight vowels, as opposed to the six vowels found in SA. The short vowels consist of (a, i, u), along with their longer counterparts, (aː, iː, uː), in addition to two mid vowels /eː/ and /oː/ (Ingham, 1994). The syllable structure in NA encompasses the following patterns: CV, CVC, CVV, CVVC, CVCC, CCV, CCVC, CCVV, CCVVC, and CCVCC (Alqahtani, 2014), whereby by C represents consonants and V represents vowels.

Table 2: *The Obstruent Inventory of Najdi Arabic (Ingham, 1994).*

	Bilabial	Labio-Dental	Dental	Emphatic-Interdental	Alveolar	Emphatic-Alveolar	Palato-Alveolar	Velar	Uvular	Pharyngeal	Glottal
Plosives	b				t d	tˤ dˤ		k g	q		ʔ
Fricatives		f	θ ð	ðˤ	s z	sˤ	ʃ		χ ʁ	ħ ʕ	h
Affricates							dʒ				

Note. Where symbols appear in pairs, the one to the right represents a voiced consonant and the one to the left represents a voiceless consonant.

Past studies asserted that initial consonant clusters are permissible in NA (Abboud, 1979; Al-Sweel, 1990; Ingham, 1994; Owens, 1997). Alezetes (2007), building upon the finding of previous studies, tested Najdi speakers' pronunciation of English words that begin with biconsonantal clusters predicting that since NA allow initial consonant clusters, speakers would produce the English bi-consonantal clusters without any modification. The findings verified the predictions, as Najdi speakers consistently produced the clusters with 100% accuracy rate. This finding further confirmed that NA indeed allow initial consonant clusters.

Research on some Arabic dialects reveals that consonants in the surface initial clusters sequences could share the same manner or place of articulation. Palestinian Arabic, for example, allows surface initial clusters with the same place of articulation, such as /ts/ and /dn/ (Tayeh et al., 2012). Jordanian Arabic dialect allows clusters that share the same manner of articulation, for example /tb/ and /tg/ (Bani-Yasin & Owens, 1987). In addition, Yemini Arabic allows syllables to start with obstruent clusters in all four types: FF, FP, PF, and PP clusters (AL-Mamri, 2021). An example for each type is provided in 5.

(5)

Type	Example	Gloss
FF	ħsan	better
FP	ʃqoːl	he will say
PF	bxiːlu	stingy
PP	gdiːdu	new

Past research on initial consonant clusters in NA has mostly relied on auditory impressions. However, recent research start employing experimental tools in the analysis. Alghmaiz (2013) conducted an acoustic study on NA, examining the patterns of word-initial consonant clusters while considering the voice feature and measuring the sonority scale of the initial clusters. Out of the 24 words tested, 12 words acoustically confirmed the occurrence of the following initial consonant clusters: (ts, bð, ħm, ðn, rw, rj, tn, zr, mw, mj, tr, and θj). These findings further support the claims made by Abboud (1979), Al-Sweel (1987) and Ingham (1994), regarding the occurrence of initial consonant clusters in NA.

2. METHODOLOGY

A couple of methodological challenges are encountered whenever an Arabic dialect phonology is being studied. These challenges stem from the diglossic nature of the Arabic language, which features two registers: Standard Arabic and Arabic dialects. Standard Arabic is the formal and prestigious variety, while Arabic dialects are the informal varieties which are considered less prestigious. Therefore, in a formal setting such as collecting data in a laboratory environment, participants are likely to opt for the Standard variety rather than the dialect. Furthermore, Arabic orthography is primarily associated with Standard Arabic pronunciation. Thus, when collecting spoken data relying on scripted stimuli, there is a possibility to evoke the pronunciation of Standard Arabic more frequently than that of the local dialect (Alghmaiz, 2013). To further complicate matters, short vowels in Arabic are orthographically represented through optional diacritics. The absence of these diacritics in written words can lead to ambiguity particularly when taken out of context. For example, the word لبس can have more than one meaning; it could mean 'a cloth' or 'he dressed' or 'he tricked'. Therefore, collected spoken data through written stimuli is a challenging task.

Hall (2013) initiated a protocol to mitigate these challenges by using a refined elicitation method that incorporated an audio stimulus simultaneously with a visual stimulus. In this protocol, Hall created a PowerPoint presentation in which each slide displayed a target word above a carrier sentence. At the same time, while participants were viewing the slide, they heard an audio recording of a native Arabic speaker saying another example sentence containing the same target word. However, the target word in the audio was replaced by white noise (lasting for 400 ms) to avoid providing a pronunciation model. Following this protocol, participants were able to produce the dialect throughout the experiment. As a result of the successful elicitation of the desired dialect, the current research has adopted this protocol for the data collection.

2.1.Speakers

Fourteen Najdi Arabic native speakers (7 males,7 females) with no reported hearing or physical impairment were recruited. Participants were included in the study based on being born and raised in Najd. They were all living in the UK at the time of the study. Informed consent was obtained by all participants, and ethical procedures were followed as approved by the Research Ethics Committee of the University of Reading.

2.2.Material Selection

The current study focuses on clusters of two obstruents. Three criteria were followed to select real Arabic target words. Firstly, words with the syllable structure CVCVC or CVCVCV that started with an obstruent followed by a short vowel followed by another obstruent were selected because past research has shown that initial consonant clusters in Arabic occurred due to a deletion of short vowels in open syllables (Ingham, 1994). Secondly, words that have obstruent prefixes are included because these words might be produced with initial obstruent sequence (Alghmaiz, 2013; Alqahtani, 2014). Finally, words that were listed in NA past research and were assumed to start with obstruent clusters were also included in the study. Efforts were made to incorporate all four types of the obstruent clusters: FF, FP, PP, and PF in a balanced manner.

2.3.Recording Procedure

Each speaker was met individually in a sound-proof booth in the University of Reading. The researcher and the speakers were seated across from each other at a table. The recorder was table-mounted to obtain reliable data as the distance between the speakers and the recorder was held constant. It was placed around 8 inches to the right of the participant to avoid clipping and transients in the acoustic signal (Podesva & Sharma, 2013). Speech productions were recorded into a Tascam DR-07 mkll hand-held digital recorder, at a sampling rate of 44,1 KHz and 32-bit format. Beats Solo3 wireless on-ear headphones were used to listen to the audio stimuli.

2.4.The Informal Interview

The main topic chosen for the interview was a description of speakers' first day in the UK. This topic was deemed to be of shared interest to all speakers and it promoted personal narratives. The questions used in the interview were open-ended in nature, but other questions were generated spontaneously based on speakers' responses.

2.5. Reading Task

The reading task involved two parts. The first part comprised reading words embedded in carrier sentences whereas the second part included reading sentences in the form of well-known NA proverbs.

2.5.1. Reading Sentences

A PowerPoint presentation was used, in which each slide presented one target word embedded in a carrier sentence. At the same time, while viewing the slide, each speaker heard an audio recording of a Najdi native speaker saying another example sentence that included the same target word, yet, that target word was replaced by white noise (400 ms), following the elicitation protocol initiated by Hall (2013).

2.5.2. Stimuli and Design

Words that adhered to the selection criteria outlines in Section 3.2 were selected for this task (see Appendix A), ensuring that each cluster type was represented by 20 words, totalling a list of 80 words. For the audio stimuli, a Najdi male speaker aged 36 who was born, raised and received his formal Arabic education (until high school) in Riyadh, Saudi Arabia was recruited to read the audio stimuli. The speaker reported no medical or speech difficulties. Informed consent to participate in the study was obtained from the speaker before the recording. Prior to the recording, the speaker was allowed to practice reading the sentences as much as he wanted. The speaker was instructed to read the sentences clearly and at normal pace. In a quiet room in the University of Reading, the speaker was audio-recorded while reading 80 example sentences.

The audio recordings were digitally transferred to a laptop. Using version 2.3.1.0 of Audacity (Audacity, 2019), the sentences were edited. First, each sentence was cut and saved as .wav file. Then, the target word in each .wav file was replaced with a 400 ms. white noise. Finally, each sentence was uploaded in the matching slide in the main PowerPoint presentation. Each slide displayed a single centred word in Arabic orthography on the first line, with the carrier sentence, also centred, presented on the second line below it. They were typed in black, with Times New Roman font size 60, on a white background. The target words were in sentence medial position to avoid the effects of phrase-final lengthening (Podesva & Sharma, 2013).

2.5.3. Reading Speech

Well-known Najdi proverbs, that were frequently used in the spoken form, were selected as stimuli for the second part of the reading task. The purpose of using proverbs was to help speakers use the Najdi dialectal speech and to give them a real context for each word (Ibrahim et al., 2015). Another self-paced PowerPoint presentation was used, with each slide featuring one sentence centred, typed in black, with Times New Roman font at size 60 on a white background.

2.5.4. Stimuli

It was challenging to find Najdi proverbs containing words that met the same criteria mentioned in Section 3.2. The stimuli for this task consisted of twenty words naturally integrated into 18 Najdi proverbs. Among these proverbs, two contained two target words while the remaining proverbs featured one target word each. The proverbs encompassed all four types of the obstruent clusters, whereby each cluster type was represented by five words (see appendix B).

2.6.Data Elicitation Procedure

All speakers completed their recordings in a single session. The first session began with a welcome message to participants, an introduction to the recording process, and the distribution of consent forms and demographic questionnaires, which typically required 5 - 8 minutes to complete. Subsequently, the interview was conducted which lasted for about 15-20 minutes. After a short break, speakers were given a short practice set of the reading sentences to familiarize themselves with the procedure. They were provided with headphones and were allowed to adjust the volume as needed. Once the presentation started, each word was displayed for 200 ms before an automated audio stimulus was played. Speakers were instructed to read the sentences in NA at a normal pace in a clear voice after listening to the audio stimuli. The presentation was self-paced, and it lasted for about 50-80 minutes. After another short break, the second part of the reading task began featuring another self-paced PowerPoint presentation which included only written stimulus. This session lasted for about 10-15 minutes.

2.7.Data Analysis

The sound files were uploaded to a computer and analysed using Praat (Boersma & Weenink, 2018). For the interview data, as well as words from the reading task, words that met the criteria outlined in Section 3.2 were extracted and phonemically transcribed by the researcher. The transcription process was conducted in a broad way with special attention to the first syllable.

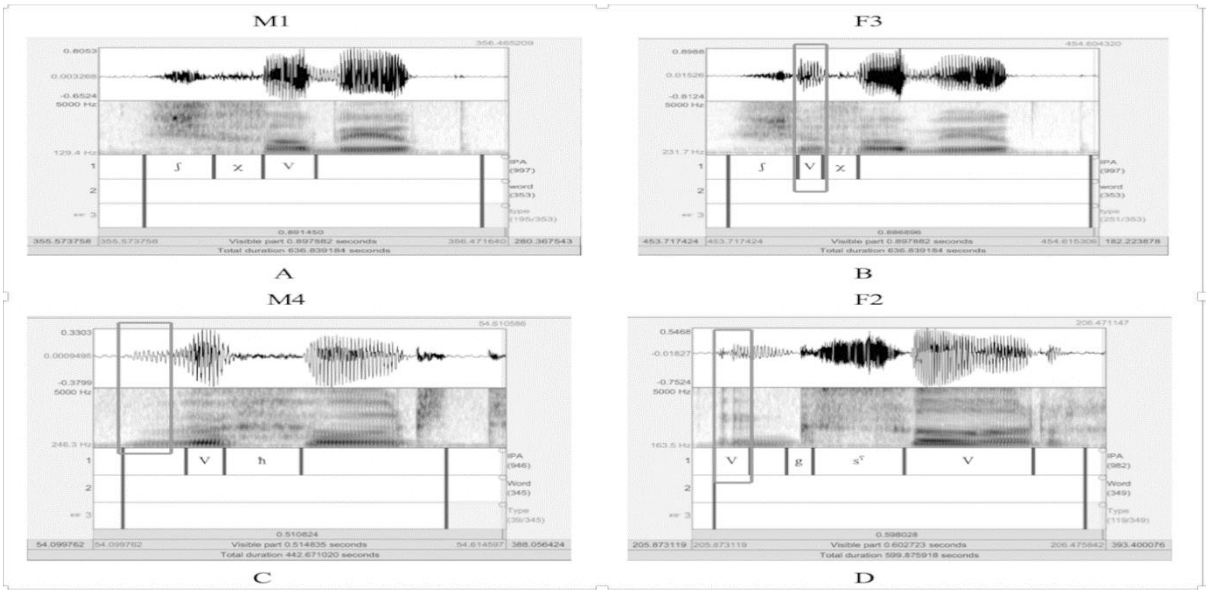
The onset and offset of the first syllable were marked in a Praat Textgrid. The waveform and spectrogram of each word were visually examined. The coding of the data followed the same procedure conducted by Davidson and Wilson (2016). The productions were classified into four categories : (1) a cluster code was assigned when no voicing nor visible first and second vowel formants existed between the two obstruents; (2) a non-cluster code was applied if visible voicing and first and second vowel formants were present between the two obstruents; (3) a deletion code was used when either of the obstruents were omitted; and (4) a prothesis code was assigned if an additional vowel with clear first and second formants was inserted initially. A summary of the codes is provided in Table 3.

Table 3 :*Production Codes*

Production Type	Definition	Example
Cluster	Target cluster is produced with no vowel formants between the obstruents.	/ħisaːb/ ⟶ [ħsaːb]
Non-cluster	Target cluster is produced with vowel formants between the obstruents.	/fiʃiːlah/ ⟶ [fiʃiːlah]
Deletion	Target cluster is produced with one of the obstruents deleted.	/bdirtah/ ⟶[dirtah]
Prothesis	Target cluster is produced with a preceding vowel.	/gduːr/ ⟶ [ᵊgduːr]

A screenshot of the sound window for each production type (cluster, non-cluster, deletion, and prothesis) was taken and displayed in Figure 2.

Figure 2 :*A Screenshot of the* Sound Window for Each Production Type.



As shown in Figure 2, the sound window (A) is a representation of the target cluster /ʃx/ when it was classified as a cluster due to the absence of vowel formants between the two obstruents. Sound window (B) shows the same target cluster, produced by speaker F3, but in this case, it was classified as non-cluster because clear vowel formants were observed between the two obstruents. Sound window (C) depicts the target cluster /bħ/ as produced by speaker M4, with the first obstruent deleted. Finally, sound window (D) shows a prothesis, characterized by the presence of clear vowel formants, preceding the target cluster /gsˤ/.

3. RESULTS

Since the main research question revolves around the occurrence of obstruent clusters and given that the data are categorical in nature, a chi-squared goodness of fit test was performed for each word in accordance with the test assumptions. The objective of the test was to evaluate the disparity between the observed and expected counts to quantify the extent of deviation in cluster production proportions as compared to non-cluster production proportions for each word. For this analysis, the a-level was set at 0.05 to achieve a 95% level of confidence. Items that were produced with 100% as initial clusters and items that were produced with 100% with no initial clusters were excluded from the test to ensure the rigor of the analysis.

3.1.The Informal Interview

The interview with each speaker yielded varying number of items encompassing initial obstruent clusters. In total, 102 items were extracted from all speakers. It was observed that attested obstruent clusters occurred in 67% of the data (N = 68 items). These clusters spanned all four obstruent cluster types, FF (N = 5), FP (N = 1), PF (N = 11), and PP (N = 9) clusters, as shown in Table 4.

Table 4 :*Obstruent Clusters*

FF	FP	PF	PP

ʃh	sˤd	ts	tt
Sh		kθ	tk
ʃs		bs	gtˤ
Sħ		tx	tb
Sf		bħ	gb
		bθ	gd
		dχ	bk
		tħ	tg
		th	kb
		tf	
		tʃ	

F = fricative, P = plosive.

The obstruent clusters resulting from the affixation processes encompassed 47% of the data. These affixation processes included adding a prefix (an obstruent) e.g., /ħeɪθ/ 'where' > /bħeɪθ/ 'in which' or adding a suffix that resulted in the deletion of the vowel in the first syllable, consequently creating initial clusters, e.g., /daxal/ 'enter' > / dxalat/ 'she entered'.

3.2.Reading Task

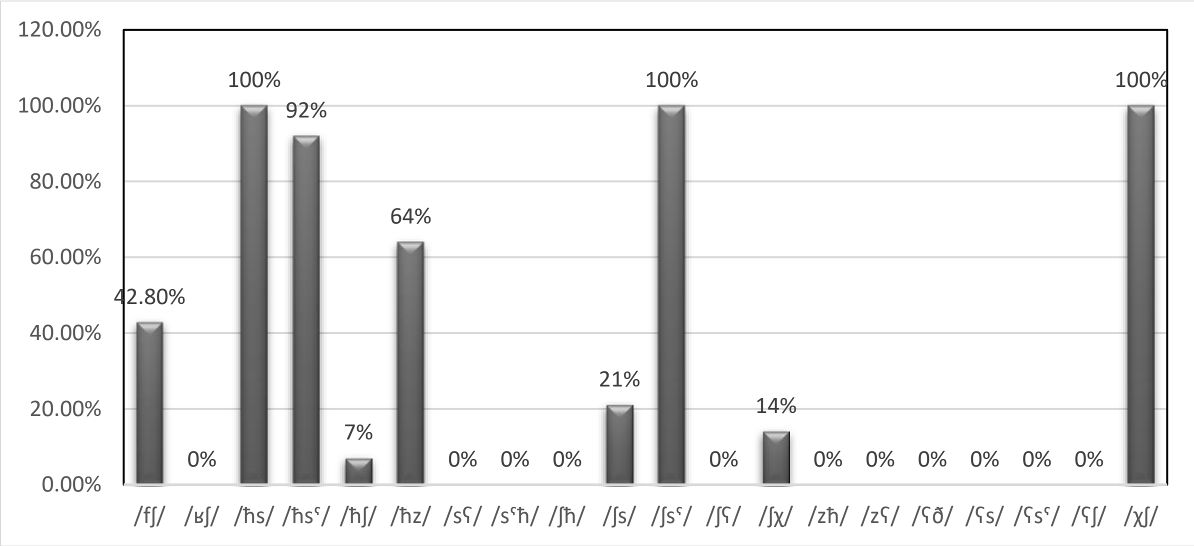
Fourteen speakers produced a total of 80 items twice, yielding 2240 tokens. Across the speakers, the production of these tokens exhibited variability, with cluster CC formation representing 44% (*N* = 982) of the total while non-cluster CVC formation made up 49% (*N* = 1105) of the data. Deletions compromised 4% (*N* = 93), protheses constituted 2% (*N* = 54), and a mere 0.2% (*N* = 6) of the data were mispronounced. In the sections that follow, each cluster type is separately analysed to determine the frequency of occurrence for each lexical item. Items that classified for deletion, prothesis or those that were mispronounced were not included in any of the analysis that follows.

3.2.1. Fricative-Fricative Cluster

Twenty items representing the FF cluster were attested throughout speakers. Three items were produced by all speakers (100%) with initial clusters (ħs, ʃsˤ, and xʃ). Seven items were never produced with initial clusters, and they all have the pharyngeal fricative /ʕ/ as either the first or the second consonant (one item has the pharyngeal /ħ/). Figure 3 displays the overall frequency of the FF cluster productions.

Figure 3

Fricative-Fricative Cluster

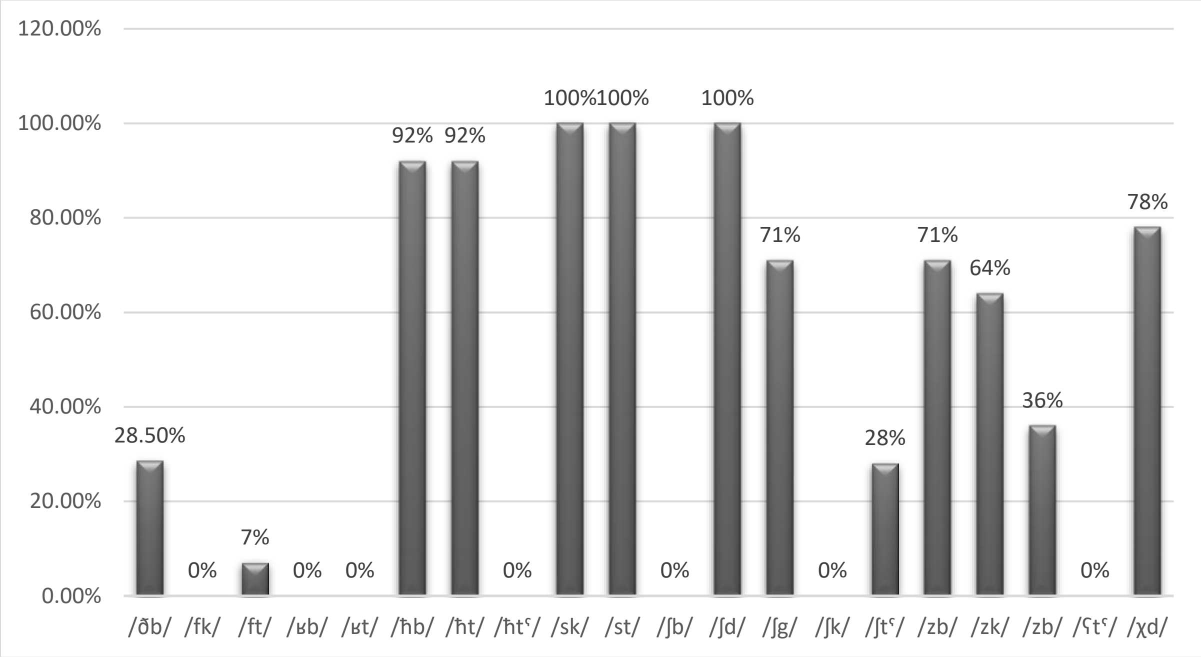


The results of the chi-square goodness of fit test showed that the distribution of the observed cluster production was consistent with the expected distribution for all clusters except for two clusters: /ʃs/ (χ^2 = 7.143, df = 1, p =.008) and /ħsˤ/ (χ^2 = 10.28, df=1, p = .001). These two FF clusters (ʃs and ħsˤ) demonstrated statistical significance in addition to the list of clusters (ħs, ʃsˤ, and xʃ), all of which displayed a cluster production rate of 100%.

3.2.2. Fricative-Plosive Cluster

Twenty items representing the FP cluster were attested throughout speakers. Figure 4 shows that three items were produced with a cluster production rate of 100% (sk, st, and ʃd), whereas six items were produced with no initial clusters (ʃb, fk, ʃk, ʁb, ʁt, ħtˤ, and ʕtˤ). None of the items with the voiced uvular fricative /ʁ/ nor the voiced pharyngeal fricative /ʕ/ were produced within a cluster.

Figure 4:*Fricative-Plosive Cluster*

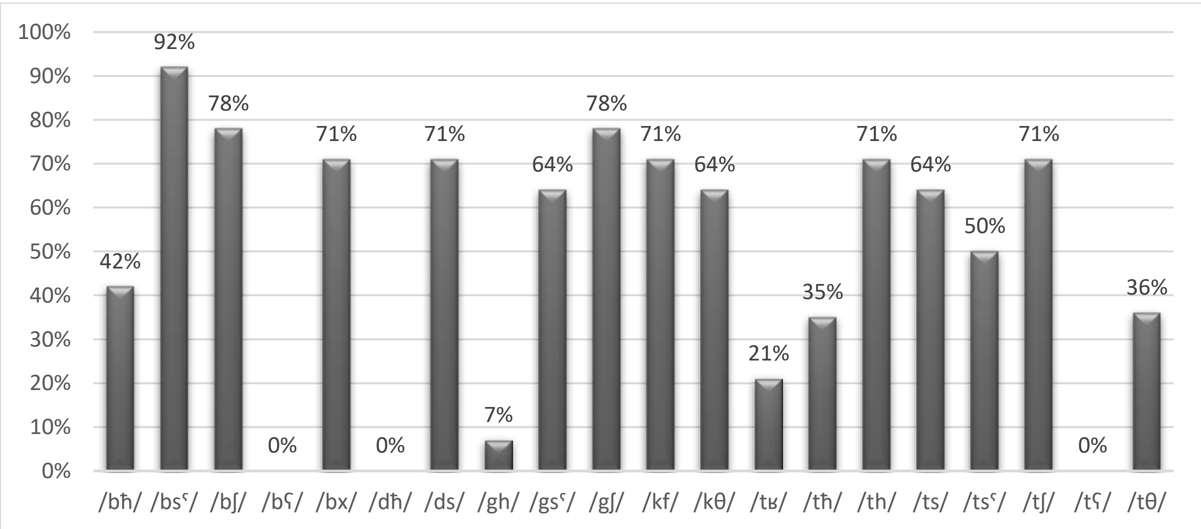


The results of the chi-square goodness of fit test showed that the distribution of the observed cluster production was not consistent with the expected distribution for the following clusters: /ħb/ cluster (χ^2 = 9.308, df=1, p = .002), /ħt/ cluster (χ^2 = 10.28, df=1, p = .001), /zb/ cluster (χ^2 = 4.455, df=1, p = .035), and /χd/ cluster (χ^2 = 6.231, df=1, p = .013). The list of the attested PF cluster along with the statistically attested ones comprises the following patterns of the attested initial obstruent clusters: sk, st, ʃd, ħb, ħt, zb, and χd.

3.2.3. Plosive-Fricative Cluster

The results of the cluster production for the twenty items representing the PF cluster are displayed in Figure 5. None of the items exhibited initial cluster production by all speakers. Three items were never produced with initial clusters (bʕ, tʕ, and dħ); they all contain a pharyngeal fricative as the second member. None of the items with the voiced pharyngeal fricative /ʕ/ were produced within a cluster.

Figure 5:*Plosive-Fricative Cluster*



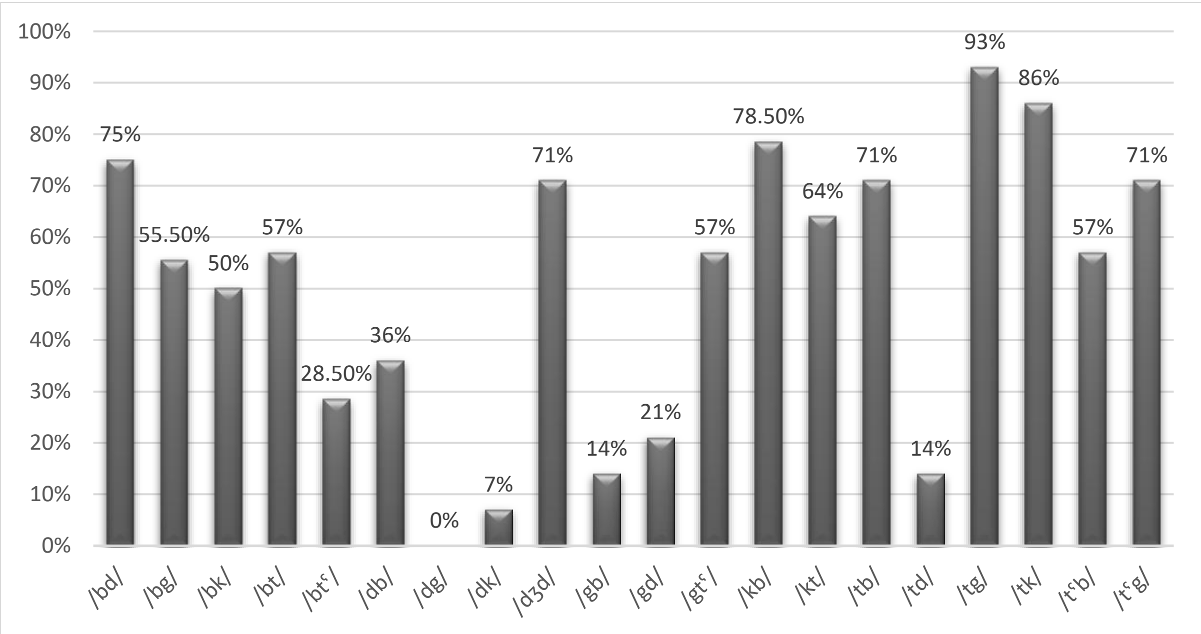
A chi-square goodness of fit test was carried out to test whether there was any significant difference between the expected distribution and the observed distribution. The result showed a significant outcome for the following clusters: /bsˁ/ cluster (χ^2 = 4.455, df = 1, p = .035), /bʃ/ cluster (χ^2 = 4.571, df = 1, p = .033), /ds/ cluster (χ^2 = 9.500, df = 1, p = .009), /gʃ/ cluster (χ^2 = 4.571, df = 1, p = .033), /bχ/ cluster (χ^2 = 9.500, df = 1, p = .009), and /tʃ/ cluster (χ^2 = 7.143, df = 1, p = .008). Thus, the attested clusters in the PF type consists of the following patterns: bsˁ, bʃ, ds, gʃ, bχ, and tʃ.

3.2.4. Plosive-Plosive Cluster

The results of the cluster production of the twenty PP clusters are shown in Figure 6. There was no item within this dataset exhibited a 100% rate of cluster production. Specifically, the item starting with /dg/ received a 0% rate of cluster production.

Figure 6

Plosive-Plosive Cluster



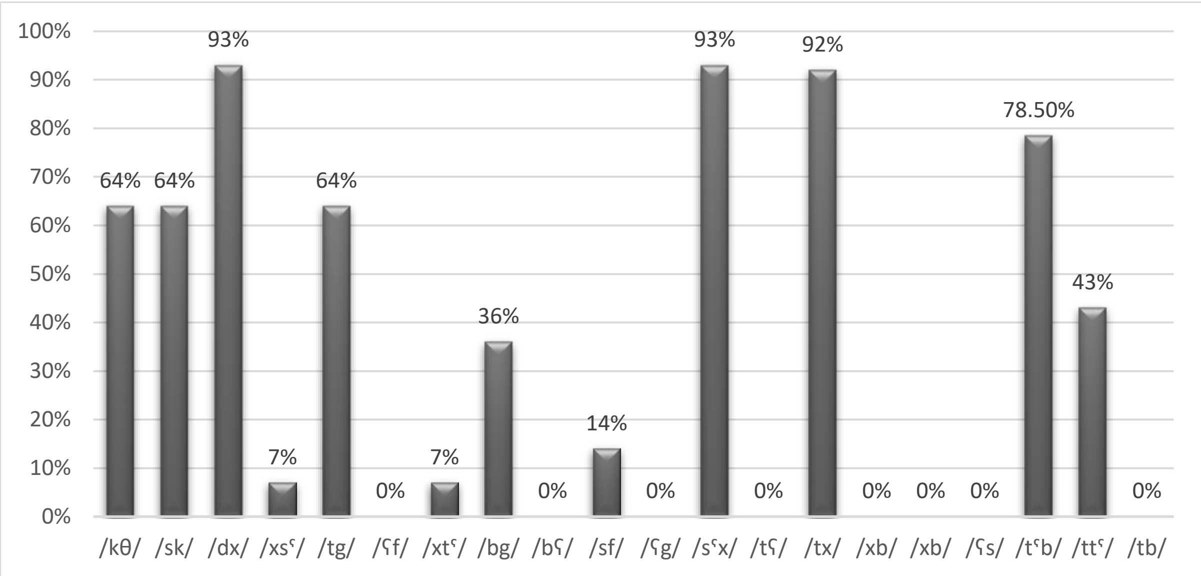
The result of the chi-square goodness of fit test revealed a significant outcome for the following clusters: /bg/ cluster (χ^2 = 6.400, df = 1, p = .011), /tb/ cluster (χ^2 = 10.286, df = 1, p = .001), /tg/ cluster (χ^2 = 10.286, df = 1, p = .001), /gd/ cluster (χ^2 = 4.571, df=1, p = .033), /tk/ cluster (χ^2 = 4.571, df = 1, p = .033), and /kb/ cluster (χ^2 = 6.400, df = 1, p = .011). The patterns that demonstrated statistically significance with respect to cluster production are: bg, tb, tg, tk, and kb.

3.4.Reading Speech

The reading speech task yielded a total of 280 items. Overall, 33% of the data (*N* = 92) were produced with initial clusters while 51% of the data (*N* = 143) were produced with no clusters (Figure 7). No item was produced by all speakers with initial cluster production. The clusters dx, tχ and sˁχ received the highest rate of cluster production, reaching 92% whereas seven items (ʕf, bʕ, ʕg, tʕ, xb, ʕs, tb) were produced without any clusters.

Figure 7

Obstruent Clusters Production



The result of the chi-square goodness of fit test revealed a significant outcome for specific clusters. These clusters are as follows: the /sˁχ/ cluster (χ^2 = 10.286, df = 1, *p* = .001), the /dχ/ and /tχ/ clusters (χ^2 = 10.286, df = 1, *p* = .001), and the /tˁb/ cluster (χ^2 = 8.333, df = 1, *p* = .004). Consequently, the initial clusters attested in the reading speech task are: sˁχ, dχ, tχ, and tˁb.

4. DISCUSSION AND CONCLUSION

This study aims to provide an initial description of word-initial obstruent clusters in NA using acoustic evidence and delineate the allowed cluster types. It endeavours to address the following research questions: Does NA allow word-initial obstruent clusters? if so, what are the types of the obstruent clusters allowed, and do they correspond to the final clusters observed in Standard Arabic. The results manifest the occurrence of obstruent clusters in word-initial position, encompassing all four types, FF, FP, PF, and PP. This finding categorizes NA dialect as a type 6 in the obstruent cluster typology (Morelli, 1999), signifying that it permits the occurrence of all four obstruent cluster types.

The findings, also, reveal that the probability of producing clusters varied by task. Speakers were more inclined to produce initial clusters in the informal interview (67%) than in the reading task (43%), suggesting an effect for the speaking style on the production of initial clusters. This finding is in line with previous findings on Najdi Arabic dialect (Alghmaiz, 2013; Alqahtani, 2014). Arabic speakers, regardless of their local dialect, tend to shift to the Standard style when reading a script (Saiegh-Haddad & Henkin-Roitfarb, 2014). This phenomenon of vowel deletion in informal social settings is found to be more frequently than that in formal settings; this observation is prevalent cross-linguistically, as exemplified by American English (Clopper et al., 2017), French (Bürki et al., 2011), Spanish (Dabkowski, 2018), and Greek (Dauer, 1980).

The obstruent clusters emerged in this study were a result of the deletion of the short vowel in the first syllable. The findings of this present study show that the formation of obstruent clusters word-initially was observed on a morphological as well as phonological level. Morphologically, the current findings show that the deletion process occurred as a result of the affixation process, as was previously suggested by Ingham (1994). Both suffixes and prefixes in this affixation process resulted in the deletion of vowels. When suffixes were attached to a word, the short vowel in the first syllable was deleted, such as /kaθar/ 'add' > /kθarat/. Similarly, when prefixes were attached to a word, the short vowel in the first syllable was deleted, such as /kifi:/ 'my mood' > /bkifi:/ 'up to my mood'. The stimuli included 35 words with affixes, 49% of these words were produced with initial clusters in over 50% of their occurrences. Thus, affixation plays a vital role in the formation of initial obstruent clusters. On a phonological level, the findings of the current study reveal that there were instances whereby obstruent clusters occurred independently, even without the influence of affixation. For example, /ħisaːb/ 'account' > /ħsaːb/. The stimulus set comprised 58 words with no affixation; the results indicated that 47% of these words were produced with initial clusters more than 50% of the time. So, it can be concluded that initial obstruent clusters in NA can be created through both phonological and morphological processes.

The findings further reveal that the deletion of short vowels included both high front vowels, such as /biχiːr/ 'fine' > /bχiːr/, and high back vowels, such as /χuʃuːm/ 'noses' > /χʃuːm/, aligning with past literature in NA (Ingham, 1994). Moreover, the findings indicate that the deletion was not exclusive to high vowels; it may also affect low vowels, an example being /bagarah/ 'cow' > /bgarah/. Hence, in NA, both high and low vowels as well as front and back vowels are prone to the deletion process.

Another noticeable observation arising from the result pertains to the realization of the vowel neighbouring the voiced pharyngeal fricative /ʕ/. Whenever this fricative was encountered, either as the first or the second obstruent in a word, the outcome resulted in the retention of the vowel situated between the obstruents, rather than the formation of a consonant cluster. This observation can be explained by considering the acoustic characteristics of this fricative. This pharyngeal fricative exhibits a formant-like structure which renders it challenging to distinguish its acoustics from that of the adjacent vowel. Al-Khairy (2005) conducted an acoustic analysis of Arabic fricatives and encountered a similar issue with the pharyngeal fricative. This difficulty in distinguishing it from the neighbouring vowel persisted, even though Al-Khairy's analysis was conducted on a simpler syllable structure (CVC), whereas the current analysis involved a more complex syllable structure.

Similarly, Al-Ani (1970) revealed that the realization of the uvular and pharyngeal fricatives is often more sonorant than that typical of a fricative. Building upon the preceding observations, Laufer (1996) conducted an examination of the pharyngeal fricatives /h/ and /ʕ/ within fluent speech. Through acoustic analysis and physiological scrutiny, Laufer's research reinforced the idea that /ʕ/ was realized as an approximant pharyngeal, whereas /h/ functioned as a fricative, thereby substantiating the earlier findings regarding the status of the pharyngeal fricative.

In terms of the phonotactics of the permissible obstruent clusters, the findings indicate that FF cluster yielded 10 patterns, FP cluster yielded 8 patterns, PF cluster yielded 16 patterns, and PP cluster yielded 12 patterns, as summarized in Table 5. Overall, there are obstruents that can occur as either the first or the second member in the obstruent cluster. These obstruents consist of s, sˤ, ʃ, ħ, χ, b, t, d, k, g, tˤ. Notably, only one obstruent /z/ occurs as the first member in the cluster /zb/. Conversely, three fricatives (f, h, and θ) were exclusively found as the second member in the cluster. The plosives /b/ and /t/ frequently co-occurred with various obstruents, primarily due to their utilization as prefixes to convey verbal morphology.

Table 5

A Summary of the Obstruent Cluster Patterns

FF	FP	PF	PP
sˤχ	st	bχ	gtˤ
Sħ	sk	bs	gb
Sh	sˤd	bsˤ	gd
Sf	χd	bʃ	tg
χʃ	zb	bθ	tk
ʃs	ħb	bħ	tˤb
ʃsˤ	ħt	gʃ	tt
ʃh	ʃd	tħ	tb
Ħs		ts	bg
ħsˤ		tʃ	bk
		tχ	bt
		th	kb
		tf	
		kθ	
		ds	
		dχ	

The patterns of the obstruent clusters identified in NA are not exclusive to this dialect but are also prevalent in various other Arabic dialects and languages around the world. Some patterns are in accord with other permissible clusters found in Northern Jordanian Arabic (Ei-Badarin, 1993), Moroccan Arabic (EI Medlaui & François, 2002), Iraqi Arabic (Erwin, 2004), and Yemeni Arabic (AL-Mamri, 2021). Some of these obstruent cluster patterns have been documented in languages beyond the realm of Arabic, including Georgian (Chitoran, 1998), Tsou (Wright, 1996) English (Ryu & Hong, 2013), and Hebrew (Kreitman, 2008). Overall, the consistent occurrence of similar obstruent cluster patterns in NA, along with their alignment with analogous patterns in various Arabic dialects and other languages, underscores the universality and cross-linguistic relevance of these phonological phenomena, emphasizing the need for comprehensive linguistic analysis and cross-linguistic research.

The examination of the surface obstruent clusters in NA reveals that some of these clusters are juxtaposed with pre-existing clusters in final positions in Standard Arabic. Out of the 46 permissible clusters under examination, 16 are found to already exist in word-final position in Standard Arabic. The list of these obstruent clusters is given in Table 6. This observation sheds light on the interplay between emerging and established phonological structures. It underscores the presence of a substantial overlap between newly emerging surface clusters and pre-existing ones, offering valuable insights into the evolving phonological landscape of this Arabic dialect and the degree of continuity and adaptation within its phonological system.

Table 6

Obstruent Clusters Patterns that Match Standard Arabic Word-Final Clusters

FF	FP	PF	PP
Sf	sk	bʃ	kb
Sħ	ʃd	bs	tˤb
Ħs	ħb	ds	
ħsˤ	ħt	bħ	
	sˤd	bχ	

F = fricative, P = plosive.

To conclude, the current study provides a description of the initial obstruent clusters that surface in NA, an area that has received little prior investigation. The acoustical evidence confirms that NA allows initial obstruent clusters. The study attests all four types of obstruent clusters in NA, namely PP, FF, PF and FP, revealing a rich array of obstruent cluster patterns within the dialect. Furthermore, the study demonstrates that the deletion process targets short vowels, both high and low, as well as those that are front and back. Finally, while several obstruent clusters were a match with word-final clusters in Standard Arabic, several new clusters emerge that are absent in Standard Arabic, reflecting a much wider inventory of surface obstruent clusters. The present study makes a significant contribution to our understanding of surface obstruent clusters in NA.

Acknowledgment

This research has been supported by Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia. Special thank goes to the fourteen participants who took part in this study. Their time, patience and cooperation are highly appreciated. We also would like to thank Prof. Alexei Kochetov for the valuable criticism of earlier parts of this work.

REFERENCES

Abboud, P. F. (1979). The verb in northern Najdi Arabic. *Bulletin of the School of Oriental and African Studies, 42*(3), 467-499.

Al Tamimi, Y. A. S., & Al Shboul, Y. (2013). Is the phonotactics of the Arabic complex coda sonority-based? *Journal of King Saud University - Languages and Translation, 25*(1), 21-33. https://doi.org/10.1016/j.jksult.2012.12.003

Al-Ani, S. (1970). *Arabic phonology*. The Hague.

Al-Khairy, M. A. (2005). *Acoustic characteristics of Arabic fricatives* [PhD dissertation, University of Florida]. ProQuest Dissertations & Theses Global; ProQuest One Literature. https://www.proquest.com/docview/304994659?accountid=13042

AL-Mamri, M. J. (2021). Patterns of consonant clusters in word initial, medial, and final positions in Yemeni Arabic. *Journal of Linguistics, Literature and Language Teaching, 7*(1), 41-51. https://doi.org/10.32505/jl3t.v7i1.2821

Al-Sweel, A. (1987). Verbal and nominal forms of Najdi Arabic. *Anthropological Linguistics, 29*(1), 71-90.

Al-Sweel, A. (1990). Some aspects of Najdi Arabic phonology. *Zeitschrift Für Arabische Linguistik*(21), 71-82. http://www.jstor.org/stable/43615789

Alezetes, E. (2007). *A markedness approach to epethesis in Arabic speakers' L2 English* The University of Montana]. Missoula.

Alfaifi, A. A. (2019). *Syllabification of coda consonant clusters in Najdi and Hijazi Arabic* [Master's thesis, George Mason University]. ProQuest Dissertations Publishing. https://www.proquest.com/docview/2305028297?pq-origsite=gscholar&fromopenview=true

Alghmaiz, B. A. (2013). *Word-initial consonant cluster patterns in the Arabic Najdi dialect* [Master's thesis, Southern Illinois University]. ProQuest Dissertations Publishing. https://go.exlibris.link/Zm4ckSLF

Alqahtani, M. (2014). *Syllable structure and related processes in Optimality Theory: An examination of Najdi Arabic* [Doctoral dissertation, Newcastle University]. Newcastle University. http://hdl.handle.net/10443/2757

Alsudais, A., Alotaibi, W., & Alomary, F. (2022). Similarities between Arabic dialects: Investigating geographical proximity. *Information Processing & Management, 59*(1), 102770. https://doi.org/10.1016/j.ipm.2021.102770

Audacity. (2019). *Audacity (R).* In (Version 2.3.1)

Bani-Yasin, R., & Owens, J. (1987). The phonology of a Northern Jordanian Arabic dialect. *Zeitschrift der Deutschen Morgenländischen Gesellschaft, 137*(2), 297-331. http://www.jstor.org/stable/43379559

Boersma, P., & Weenink, D. (2018). *Praat: Doing phonetics by computer [Computer program].*

Bürki, A., Fougeron, C., Gendrot, C., & Frauenfelder, U. H. (2011). Phonetic reduction versus phonological deletion of French schwa: Some methodological issues. *Journal of Phonetics, 39*(3), 279-288. https://doi.org/10.1016/j.wocn.2010.07.003

Chitoran, I. (1998). Georgian harmonic clusters: Phonetic cues to phonological representation. *Phonology, 15*(2), 121-141. https://www.jstor.org/stable/4420124

Clopper, C. G., Mitsch, J. F., & Tamati, T. N. (2017). Effects of phonetic reduction and regional dialect on vowel production. *Journal of Phonetics, 60*, 38-59. https://doi.org/10.1016/j.wocn.2016.11.002

Dabkowski, M. F. (2018). *Variable vowel reduction in Mexico City Spanish* [Doctoral dissertation, The Ohio State University]. OhioLINK Electronic Theses and Dissertations Center. http://rave.ohiolink.edu/etdc/view?acc_num=osu1531994893143203

Dauer, R. M. (1980). The reduction of unstressed high vowels in modern Greek. *Journal of the International Phonetic Association, 10*(1-2), 17-27. https://doi.org/10.1017/S0025100300002073

Davidson, L. (2006). Schwa elision in fast speech: Segmental deletion or gestural overlap? *Phonetica*, *63*(2-3), 79-112. https://doi.org/10.1159/000095304

Davidson, L., & Wilson, C. (2016). Processing nonnative consonant clusters in the classroom: Perception and production of phonetic detail. *Second Language Research, 32*(4), 471-502.

Delforge, A. M. (2008). Unstressed vowel reduction in Andean Spanish. Selected proceedings of the 3rd Conference on Laboratory Approaches to Spanish Phonology, Victoria College at the University of Toronto.

EI Medlaui, M., & François, D. (2002). *Syllables in Tashlhiyt Berber and in Moroccan Arabic* . Kluwer Academic Publishers.

Ei-Badarin, M. (1993). Consonant clusters in a Northern Jordanian Arabic dialect. *29*(2), 201-242. http://hdl.handle.net/10371/85968

Erwin, W. M. (2004). *A short reference grammar of Iraqi Arabic*. Georgetown University Press.

Fujimoto, M. (2015). Vowel devoicing. In H. Kubozono (Ed.), *Handbook of Japanese phonetics and phonology* (Vol. 2, pp. 167-214). De Gruyter. https://doi.org/10.1515/9781614511984.167

Hall, N. (2013). Acoustic differences between lexical and epenthetic vowels in Lebanese Arabic. *Journal of Phonetics, 41*(2), 133-143. https://doi.org/10.1016/j.wocn.2012.12.001

Hirayama, M. (2009). *Postlexical prosodic structure and vowel devoicing in Japanese*. University of Toronto.

Ibrahim, H., Abdou, S., & Gheith, M. (2015). Idioms-proverbs lexicon for Modern Standard Arabic and colloquial sentiment analysis. *Internation Journal of Computer Applications*, *118*(11), 26-31.

Ingham, B. (1994). *Najdi Arabic: Central Arabian*. John Benjamins Publication Company.

Kreitman, R. (2008). *The phonetics and phonology of onset clusters: The case of Modern Hebrew* [Doctoral dissertation, Cornell University]. Cornell University Library. https://hdl.handle.net/1813/9456

Laufer, A. (1996). The common [ʕ] is an approximant and not a fricative. *Journal of the International Phonetic Association, 26*(2), 113-118. https://doi.org/10.1017/S0025100300006150

Morelli, F. (1999). *The Phonotactics and phonology of obstruent clusters in optimality theory* [Doctoral dissertation, University of Maryland]. USA.

Ogasawara, N. (2013). Lexical representation of Japanese vowel devoicing. *Language and Speech*, *56*(1), 5-22. https://doi.org/10.1177/0023830911434118

Owens, J. (1997). *Najdi Arabic: Central Arabian*. John Benjamins Publishing Company.

Podesva, R. J., & Sharma, D. (Eds.). (2013). *Research methods in linguistics*. Cambridge University Press.

Prochaska, T. (1988). *Saudi Arabian dialects*. Kegan Paul International. (London: Kegan Paul International)

Roettger, T. (2019). Researcher degrees of freedom in phonetic research. *Laboratory Phonology 10*(1). https://doi.org/10.5334/labphon.147

Ryu, N.-Y., & Hong, S.-H. (2013). Schwa deletion in the conversational speech of English: The role of linguistic factors. *Linguistic Research, 30*(2), 313-333. http://isli.khu.ac.kr/journal/content/data/30_2/8.pdf

Sabir, I., & Alsaeed, N. (2014). A brief description of consonants in Modern Standard Arabic. *Linguistics and Literature Studies*, *2*(7), 185-189.

Saiegh-Haddad, E., & Henkin-Roitfarb, R. (2014). The structure of Arabic language and orthography. In E. Saiegh-Haddad & R. M. Joshi (Eds.), *Handbook of Arabic literacy: Insights and perspectives* (pp. 3-28).

Tayeh, Q., Daana, H., & Tahaineh, Y. (2012). Consonant Clusters in Toulkarim Palestinian dialect. *European Journal of Scientific Research*, *88*(1), 45-84.

Vennemann, T. (2012). Structural complexity of consonant clusters: A phonologist's view. In P. Hoole, L. Bombien, B. kühnert, C. Mooshammer, & M. Pouplier (Eds.), *Consonant clusters and structural complexity* (Vol. 26, pp. 11-32). De Gruyter Mouton. https://doi.org/10.1515/9781614510772.11

Whang, J. (2018). Recoverability-driven coarticulation: Acoustic evidence from Japanese high vowel devoicing. *The Journal of the Acoustical Society of America*, *143*(2), 1159-1172. https://doi.org/10.1121/1.5024893

Wright, R. A. (1996). *Consonant clusters and cue preservation in Tsou* [Doctorate dissertation, University of California, Los Angeles]. ProQuest Dissertations & Theses Global; ProQuest One Literature. https://www.proquest.com/dissertations-theses/consonant-clusters-cue-preservation-tsou/docview/304274301/se-2

Zaidan, O. F., & Callison-Burch, C. (2014). Arabic Dialect Identification. *Computational linguistics - Association for Computational Linguistics*, *40*(1), 171-202. https://doi.org/10.1162/COLI_a_00169

Appendices

Appendix A

List of Words of the Reading Sentences Task

OC	FF	Gloss	OC	FP	Gloss
fʃ	/fiʃilah/	shameful	ðb	/ðubɑːtˤ/	officers
ʁʃ	/ʁaʃaːʃ/	a cheater	fk	/fakit/	I opened
ħs	/ħisaːb/	an account	ft	/fataħah/	opener
ħsˤ	/ħisˤɑːn/	a horse	ʁb	/ʁubaːr/	dust
ħʃ	/ħaʃiːmah/	respect	ʁt	/ʁatrah/	a head cloth*
ħz	/ħizaːm/	a belt	ħb	/ħibaːl/	robes
sʕ	/saʕafah/	a palm frond	ħt	/ħitaːt/	crumbles
sˤħ	/sˤuħuːn/	dishes	ħtˤ	/ħatˤiːt/	I put
ʃħ	/ʃaħaðah/	begging	sk	/sakaka/	city name*
ʃs	/ʃasaːlfa/	what's going on?	st	/sitarah/	curtains
ʃsˤ	/ʃasˤɑːr/	what happened?	ʃb	/ʃubaːk/	a window
ʃʕ	/ʃaʕiːr/	barley	ʃd	/ʃadaʕwah/	don't take it seriously
ʃχ	/ʃaχabˤiːtˤ/	scribbles	ʃg	/ʃuguːg/	holes

zħ	/zaħa:lig/	slides	ʃk	/ʃaka:k/	Paranoid
zʕ	/zaʕalat/	she is mad	ʃtˤ	/ʃitˤarah/	canniness
ʕð	/ʕiða:m/	bones	zb	/zibala/	trash
ʕs	/ʕasah/	I wish	zk	/zuka:m/	Flu
ʕsˤ	/ʕusˤfu:r/	a bird	zb	/zabirih/	a type of shoes*
ʕʃ	/ʕaʃa:nk/	for you	ʕtˤ	/ʕatˤʃa:n/	thirsty
χʃ	/χuʃu:m/	noses	χd	/χudu:d/	cheeks
OC	PF	Gloss	OC	PP	Gloss
bħ	/buħu:r/	seas	bd	/bidirtah/	in his town
bsˤ	/bisˤa:tˤ/	a mat	bg	/bigarah/	a cow
bʃ	/biʃa:rah/	good news	bk	/bikifi/	up to me
bʕ	/biʕi:r/	a camel	bt	/bitalat/	continues “fem. sig”
bχ	/biχi:r/	fine	btˤ	/bitˤa:gah/	a card
dħ	/diħdirah/	lowland	db	/dibaʃa/	foolish
ds	/dusu:s/	gloves	dg	/dagit/	I called
gh	/gahwah/	coffee	dk	/daka:n/	a shop
gsˤ	/gusˤu:r/	castles	dʒd	/dʒida:r/	a wall
gʃ	/guʃu:r/	crusts	gb	/gubu:r/	graves
kf	/kufu:f/	slaps	gd	/gudu:r/	pots
kθ	/kaθarat/	gets more “fem. sig”	gtˤ	/gitˤawah/	cats
tʁ	/tiʁa:mir/	takes a risk “fem. sig”	kb	/kiba:r/	Large
tħ	/tiħali:l/	medical tests	kt	/kita:b/	a book
th	/tuhama/	name*	tb	/tuba:lay/	exaggerates “fem. sig”
ts	/tistahbil/	Jokes around	td	/tadu:m/	continues “fem. sig”
tsˤ	/tusˤu:m/	fasts “fem. sig”	tg	/tiga:miz/	jumps “fem. sig”
tʃ	/tiʃi:l/	picks up “fem. sig”	tk	/tikalam/	talks “fem. sig”
tʕ	/taʕalam/	teaches “fem. sig”	tˤb	/tˤubu:l/	drums

OC = obstruent clusters, F = fricative, P = plosive, “*” = a proper noun

Appendix B

List of Words of the Reading Speech Task

OC	FF	Gloss	OC	FP	Gloss
χsˤ	/χasˤiːmak/	your enemy	sk	/sikakinha/	their knives
ʕf	/ʕifnah/	abandoned	ʕg	/ʕigal/	brain
sˤχ	/sˤiχalah/	a baby goat	χb	/χubazin/	bread
sf	/sufahaha/	uneducated	χb	/χibaztih/	you baked
ʕs	/ʕisarak/	difficult times	χtˤ	/χutˤabaha/	Prospective grooms
OC	PF	Gloss	OC	PP	Gloss
kθ	/kaθarat/	gets more “fem. sig”	tg	/tugaði/	sue
dχ	/daχalat/	enters “fem. sig”	bg	/bigalbah/	in his heart
tʕ	/taʕaːwanu/	cooperate “pl”	tˤb	/tˤubiʕ/	habit
tχ	/tuχalf/	recoup “fem. sig”	ttˤ	/tutˤalaʕah/	get it out
bʕ	/biʕiːd/	far away	tb	/tibih/	wants

OC = obstruent clusters, F = fricative, P = plosive.