



Phonological development in 3-5 years old Bahdini Kurdish-speaking children

Aveen Mohammed Hasan¹

Duhok University

Rezheen Salih Ahmed²

Zakho University

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Abstract

Studying phonological development is crucial for understanding linguistic patterns, supporting language preservation, educational development and clinical practice. There is lack of sufficient research about phonological development in the Kurdish language. The aim of this study is to examine the phonological development in typically developing Bahdini Kurdish (BK)-speaking children. The analysis uses the quantitative phonological development metrics that assess the correctness of a single segment such as Percentage of Consonant Correct (PCC), Percentage of Vowel Correct (PVC) and Percentage of Phoneme Correct (PPC) and those that evaluate the whole words abilities instead of mere segments such as Phonological Mean Length of Utterance (PMLU), Proportion of Whole-Word Proximity (PWP) and Proportion of Whole-Word Correctness (PWC). The study assessed 54 monolingual BK-speaking children aged 3 to 5 years randomly selected from kindergartens in Zakho city. The assessment was carried out using the Bahdini Kurdish Articulation Test (Ahmed & Hasan, 2022). The results show that the mean score of segmental phonological accuracy measures for PCC is 89.36, for PVC 96.35 and for PPC 93.66. The whole-word skills mean score measures for PMLU is 6.99, for PWP 0.93 and for PWC 0.71. These scores show low rates of phonological metrics which indicate that phonological development is later in BK children in comparison to that of other languages. There is a significant effect of age on these measures, while no effect of gender is observed. The study of phonological development of BK is significant for cross-linguistic research or practical applications in speech pathology. It presents valuable opportunities for empirical and theoretical contributions to the broader understanding of human language and cognition.

Keywords: phonological development, Bahdini Kurdish, phonological accuracy, whole-word abilities, phonological metrics

1. Introduction

Phonological development or phonological acquisition is a critical aspect of language acquisition in children, involving the gradual mastery of the sound system of a language. It focuses on how children acquire the phonological system of the ambient language(s), learn the phonological rules, produce contrasts between phonemes and combine these phonemes in

¹ Dr. Aveen Mohammed Hasan is an assistant professor currently working at Duhok University. She is specialized in General Linguistics. Her research area covers phonetics, phonology. Email: aveen.hasan@uod.ac. ORCID: <https://orcid.org/0000-0002-9974-9665>

² Mrs. Rezheen Salih Ahmed is an assistant lecturer currently working at Zakho University. She is specialized in Linguistics. Her research area covers applied linguistics, language acquisition. E-mail: rezheen.ahmed@uoz.edu.krd. ORCID: <https://orcid.org/0009-0004-9737-788X>

words (Saaristo-Helin, 2011). Although, there are distinguishable phases in phonological development (e.g. the prelexical period and the first word period), differences among children acquiring the same language make it challenging to define clear-cut developmental stages (Saaristo-Helin, 2011).

Phonological development has been analyzed using different qualitative and quantitative methods. Qualitative methods involve phoneme inventory analyses (e.g. Stoel-Gammon, 1985), the analysis of word templates produced by the child (Menn, 1983; Vihman, 2010) and the analysis of phonological processes in the child's speech (Ingram, 1981; Grunwell, 1987). Quantitative analyses measure the child's progress using some quantitative metrics. Several assessment tools for measuring children's phonological development have been proposed. Some of them are segment oriented, i.e. they only assess the correctness of a single segment such as: Percentage of Consonant Correct (PCC), Percentage of Vowel Correct (PVC) and Percentage of Phoneme Correct (PPC) or a number of segments in a sequence such as Percentage of Consonant Cluster Correct (PCCC). Other methods evaluate the whole words instead of mere segments, such as: Phonological Mean Length of Utterance (PMLU), Proportion of Whole-Word Proximity (PWP) and Proportion of Whole-Word Correctness (PWC). These metrics are increasingly important because the child's results can easily be compared to those of others and they provide a useful method for evaluating improvement in therapy (Saaristo-Helin, 2011). They are also used for understanding phonological development in children with phonological disorders, accurately diagnosing them and tracking their progress (Huneety et al., 2024). Additionally, they can work as universal or as language independent metric of phonology (Saaristo-Helin, 2011). This study will analyze the phonological development in Bahdini Kurdish (BK) using the quantitative segmental (PCC, PVC and PPC) and whole-word (PMLU, PWP, PWC) measures.

PCC, PVC and PPC are important in the documentation of children's phonological accuracy (Dodd et al., 2003; Fatemi-Syadar et al., 2018; McLeod & Crowe, 2018; Zarifian et al., 2014; Zarifian et al., 2013). The PCC, also known as the Articulation Competence Index (ACI) (Syadar et al., 2018), serves as an index of severity of involvement that reflects three aspects of phonological disorder in children: disability, intelligibility and handicap (Saaristo-Helin, 2011). To measure PCC, the number of consonants produced correctly in a child's production is divided by the total number of consonants and then that sum is multiplied by 100 to obtain a percentage (Shriberg et al., 1997). Only correctly articulated consonants are scored as correct on the PCC, while cases of consonants deletion or substitution are scored as incorrect (Shriberg et al., 1997). The PVC is another metric that computes the number of vowels and diphthongs produced correctly. Like PCC, cases of vowels deletion and substitution are considered incorrect (Shriberg et al., 1997). The PPC reflects the percentage of both consonants and vowels/diphthongs articulated correctly (Dollaghan et al., 1993).

Whole-word phonological measures not only evaluate single segments but also all the segments that constitute the child's target word. PMLU is a diagnostic and clinical criterion in phonological development used for assessing whole-word complexity for both words targeted by the children and words that the children produce. It can be calculated out of the utterance



sample of the child's transcribed speech sample. It is scored by calculating all consonants and vowels of the child's produced words and those of the target words (standard production of words in native adults) individually. Since languages are distinctive in syllabic and phonological structures, PMLU is studied as a language-specific measure. In its earliest forms, PMLU evaluates four features of children's phonological development: proximity, complexity, correctness and variability (Karimian, Mohammadi, Bemani, Kazemi & Kianfar, 2022). Proximity indicates the correctness of the word: when the child produces the word correctly, the proximity ratio of the whole word becomes one. Complexity deals with the phonetic complexity of a child's productions. According to Stoel-Gammon (2010), complexity has three domains: word patterns (words with more syllables are generally considered complex), syllable structures (syllables with consonant clusters are complex) and sound classes (words that include less common or more difficult-to-produce or late acquired sound classes are considered complex). Correctness reflects the correct production of all components (consonants and vowels) of the word chain. Variability shows how children produce words independent of their phonological form (Ingram, 2002). The basic idea of this measurement is that children target whole words during the very early stages of phonological development and show little awareness of the segments in the words they are targeting and producing (Ingram, 2002). The PWP is another phonological quantitative measure scored by the ratio of the produced PMLU to the targeted word PMLU. PWP identifies speech intelligibility indirectly (Ingram, 2002; Babatsouli et al., 2014). It reflects the degree of accuracy in the words, for instance, if a child produced all words entirely correctly, the child would receive a PWP score of 1.0 (Saaristo-Helin, 2011). The PWC is measured simply by calculating the total number of words that the child produces correctly divided by the total number of words in a sample. For instance, if a child produced 75 words entirely correct from a sample of 100 words, the PWC value would be $75/100=0.75$, that is 75%.

These quantitative measures have been applied to a variety of languages (Ingram, 2002; Karimian et al., 2022), used to assess sample utterances of monolingual or bilingual speakers (Bunta et al., 2009), normal or phonologically impaired children across languages (Archana et al., 2011; Huneety et al., 2024). No studies have assessed the phonological development in BK-speaking children using segmental and whole-word production metrics. This study is the first attempt to examine the phonological development in typically developing monolingual BK-speaking children using both segmental and whole-word measures. Both types of measures are useful means to evaluate children's phonological abilities. Detailed knowledge about phonological development in children acquiring Kurdish or any other language provides important information for the assessment of whether a child's speech is typical, delayed or disordered (Fatemi-Syadar et al., 2021, Huneety et al., 2024).

A few studies on phonological development in Kurdish exist to date. These studies had used qualitative methods (as the study of phonological processes in the child's speech (for BK Ahmed, 2023) or the acquisition of consonant phonemes (for Central Kurdish Karzan & Sherwan, 2021) and qualitative methods that were found only for some dialects of Kurdish

(Mukryani subdialect of Central Kurdish by Fatemi-Syadar et al, 2018 and Fatemi-Syadar et al. 2021). The qualitative analysis involved Ahmed (2023) who evaluated the phonological development of 48 BK children aged 3-5 years old and identified the common phonological processes used in the first stages of their language acquisition. The study was carried out using the Bahdini Kurdish Articulation Test (Ahmed & Hasan, 2022). The results showed that the children showed 19 different patterns during the time frame under study. The most commonly used process was cluster reduction while the least used one was reduplication. No gender differences in the number and types of phonological processes had been found, while significant differences between age groups were observed (Ahmed, 2023). In her study, Ahmed (2023) also examined the consonant and vowel production accuracy. It was found that vowels were fully acquired before the age of 3, while some consonants were fully acquired before age 3, there were difficulties in mastering some consonant sounds in the three age groups under study and some consonants did not reach the mastery level even after age 5 (such as b, g, v, ɣ and j/. Similarly, Karzan & Sherwan (2021) investigated the acquisition of consonant sounds by 15 Central Kurdish speaking children aged 2:1-6:5 years old. The study used picture-naming method to elicit words containing the Kurdish consonants in three word positions: initial, middle and final. The results showed that the children acquired most consonants between age 4:6, and the sounds /s,z, ʃ, l, t, r, r/ were acquired lately in Kurdish. Quantitative analysis involved Fatemi-Syadar et al. (2018) who analyzed the normal development of PCC in terms of articulation and position of sound in the word. In their study, 120 Mukryani Kurdish-speaking children aged 3-5 years were evaluated by a Kurdish phonetic test. The results showed that the PCC increased with age and did not show any significant gender differences. It was also found that PCC was related to the manner of articulation (the children were accurate in the pronunciation of nasal, glide, lateral, stop and flap than fricative, affricative and trill consonants) and the position of sound in words (consonants in the initial position were produced better and were more precise than consonants in the medial and final position). Similarly, Fatemi-Syadar et al. (2021) examined the phonological acquisition in 120 typically developing children speaking Mukryani subdialect of Central Kurdish using the Kurdish Speech Test. Their analysis focused on the age of consonants acquisition, phonological accuracy, phonological patterns and the effect of age and gender on speech sound acquisition. The results found that Kurdish-speaking children had acquired all the vowels before 3;0 and all the consonants in the three positions (initial, medial and final) up to 4;6 years old. Consonant production in initial position was more accurate than in medial and final positions. The accuracy of Kurdish vowels and consonants improves with increasing age as phonological patterns decrease. There was no significant gender difference within the age groups.

The findings of these studies cannot be confidently generalized to other dialects and accents of Kurdish because there are phonological differences between the dialects of Kurdish. For example, there are differences in the phonemic inventory of BK and other dialects of Kurdish, for instance, The aspirated sounds / p^h, t^h, k^h, tʃ^h/ and pharyngealized plosive /t^ʕ/ are



phonemic in BK, while velar nasal /ŋ/ and velarized lateral /ɫ/ phonemes are only found in Sorani dialect (Hasan, 2012; Öpengin, 2020). The long vowels /u: and o:/ are found in BK (Khan & Salih, 2017) but not in Central Kurdish (Hamid, 2015).

This study aims to investigate and document phonological accuracy (including PCC, PVC, PPC) and whole-word abilities (including PMLU, PWP and PWC) in BK children aged 3-5.

In this study, three questions are answered:

- 1- What is the phonological accuracy for BK typically developing children?
- 2- What are the whole-word abilities for BK typically developing children?
- 3- Is there a gender and age effect on phonological accuracy and whole-word phonological abilities?

This study can be used as a basis for quantitative studies in the field of children's phonological assessment in BK. It provides a detailed understanding of how Kurdish-speaking children acquire and develop their phonological systems. It highlights the unique aspects of the Kurdish language and how they shape phonological development, contributing to broader theories of language acquisition.

1.1. Kurdish Language

Kurdish is an Indo-European language belonging to the Western Iranian language group of the Indo-Iranian branch family. It is spoken by people living mainly in Turkey, Iran, Iraq and Syria.

Kurdish is divided into three main dialects: Northern Kurdish (more widely known as Kurmanji), Central Kurdish (also known as Sorani and middle Kurmanji) and Southern Kurdish (also known as Kelhori, Khwarû or Pehlewani) (Kasap, 2021; Hasan, 2012). Northern Kurdish is spoken by the majority of the Kurdish population mainly in Turkey, Syria, north east of Iraq, Armenia, Azerbaijan, and northern Khurasan in Iran. The major subdialects of this dialect are Bahdini, Adyamani (Marashi), Bekrani, Birjendi, Botani, Bayezidi, Hekari, Jiwanshiri, Qocani, Senjari, Urfi, Yuneki (Judikani) and Surci. Orthographically, it has different writing systems: a modified Turkish Latin alphabet, Cyrillic letters and a modified Arabic alphabet (Thackston, 2006; Hassani, 2018). Central Kurdish is spoken in Iran and northeast part of Iraq. The major subdialects of this variety are Mukri, Erdelani, Germiyani, Sorani, Xushnaw, Pijdar, Pirani, Wermawe and Hewleri. Southern Kurdish predominates both in Iraq and Iran, in an area from Shehreban to Dinewer, Hemedan, Kirmashan and Xanekin all the way to Mendeli and Pehle and it is also the language of the populous Kakay tribe near Kerkuk and the Zengenes near Kifri. The subdialects of this variety are Bajelani, Kelhiri, Gurani, Mankili, Kenduley, Senjabi, Zengene, Kakayi and Kirmanshani. In this study, the Bahdini subdialect, spoken in Duhok, Zakho, Amedi and Akre cities of north of Iraq, of Northern Kurdish is understudy and the Kurdish words will be written in the modified Turkish Latin alphabet.

BK has 32 consonants which include 11 plosives /p/, /p^h/, /b/, /t/, /t^h/, /ʈ/, /d/, /k/, /k^h/, /g/, /q/, 11 fricatives /f/, /v/, /s/, /z/, /ʃ/, /ʒ/, /x/, /ɣ/, /h/, /ħ/, /ʕ/, three affricates /tʃ/, /tʃ^h/, /dʒ/, two nasals /m/, /n/, an alveolar lateral /l/ one flap /ɾ/, one trill /r/, and two glides /w/, /j/ (Hasan, 2012). /ʔ/ is not a phoneme in BK but is an epenthetic sound in BK that is inserted by the speakers to avoid onsetless syllables and to avoid vowel clusters (Hasan & Mohammed, 2023). The manner and place of articulation of the BK consonants are shown in Table 1.

Table 1
The consonant system of Bahdini Kurdish

	Bilabial	Labiodental	Alveolar	Palato-alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal
Fricatives		f v	s z	ʃ ʒ		x ɣ		ħ ʕ	h
Plosives	p b p ^h		t t ^h ʈ d			k k ^h g q			
Affricates				tʃ tʃ ^h dʒ					
Nasals	m		n						
Flap			ɾ						
Trill			r						
Lateral			l						
Approximants	w				j				

All consonants are produced in initial, medial and final position with the exception of /ɾ/ (medial and final only) and /h, p^h, t^h, k^h, tʃ^h/ (initial and medial only). BK has eight simple vowels: three short vowels /a/, /i/, /ɘ/ and five inherently long vowels /a:/, /i:/, /e/, /o/, and /u:/ (Bijankhan & Saleh, 2017). Table 2 shows the BK vowels. The majority of vowels occur in only two positions (middle and final), with the exception of two vowels /o/ and /i/ which never occur in the final position of words. Of these vowels, the short vowel /i/ has a special significance in syllable construction. It is very unstable, so that when it is located between two consonants, in particular in unstressed syllables, it is often indistinguishable by ear. The vowel /i/ has been compared to the schwa in English.

Table 2
The vowel system of Bahdini Kurdish

	Front	Central	Back
Close	i: i		u: ɘ
Mid-close	e		o
Mid-open	a		
Open			ɑ:

As for diphthongs, there is a disagreement about whether Kurdish has diphthong vowels or not. Studies do not include diphthongs in the vowel inventory claiming that they are combinations of a vowel + glide and that there are no minimal pairs between the diphthongs given in previous studies and the monophthongs (Hamid, 2015).

Regarding the syllable structure, BK has fewer syllable types and the consonant clusters, can include up to three segments in the initial and two



in the final parts (Shokri 2002; Hasan 2009; Ali & Abdulla, 2019). The vocalic element is the central obligatory element in a syllable, while the non-vocalic elements are optional (Marif, 1976; Shokri, 2002). Shokri (2002) identifies the following syllable patterns for BK: V (as in e /ε/ ‘yes’), VC (as in av /av/ ‘water’), CV (as in ba /ba/ ‘wind’), CCV (as in trî /tri:/ ‘grapes’), CVC (as in ber /bær/ ‘stone’), CCVC (as in brîn /bri:n/ ‘cut’), CVCC (as in dest /dæst/ ‘hand’), VCC (as in ærd /ærd/ ‘floor’) and CCVCC (as in stêng /steng/ ‘wasp’) (V stands for vowel and C for consonant). Ali and Abdulla (2019) further add CCCV as in strî /stri:/ ‘thorn’ and CCCVC as in stran /stra:n/ ‘song’. However, vowel-initial syllable structures are not allowed in BK either word-initially or medially, because they are pronounced with a glottal stop that is not part of the phonemic structure of the syllable, i.e., not a true consonant but is inserted to fill the onset position (Hasan and Mohammed 2023). Kurdish is a phonetic language because it is written as it is pronounced.

2. Methodology

This study employs a quantitative approach to investigate the phonological development of native BK-speaking children aged 3 to 5 years. The methodology is designed to systematically examine the effects of age and gender on phonological accuracy and whole-word abilities, utilizing structured data collection and analysis techniques. The study relies on the Bahdini Kurdish Articulation Test (BKAT) (Ahmed & Hasan, 2022), a reliable and culturally appropriate tool, to assess speech sound production. The following sections detail the participant selection, procedures, and data analysis methods used to ensure a rigorous and objective evaluation of phonological development in BK-speaking children.

2.1. Participants

The data of the present study were collected from 54 native BK children including both genders and spanned in age from 3 to 5 years. The children lived in Zakho, Duhok province of Kurdistan Region of Iraq. Both genders were included in the study in order to examine the effects of gender. Age groups 3, 4, 5 were chosen because it was considered to be the most suitable age groups for the aims of the study *considering that children under age 2 have limited vocabulary and often unintelligible speech, making it impractical for them to name all test images*. The participants were grouped into three age bands with 18 participants in each age group. The demographic characteristics of the participants is given in Table 3.

Table 3

Demographic characteristics of participants according to Age and gender

Age (in months)	Gender (%)		Mean (in months)	SD
	male	female		
36-47 (n=18)	10 (56)	8 (44)	41	3.6
48-59 (n=18)	9 (50)	9 (50)	54	3
60-71 (n=18)	11 (61)	7 (39)	66	3

The subjects were recruited from day-care centres and kindergartens in Zakho with the permission of their caregivers, parents and teachers using the simple random sampling in which individuals from larger population with an equal chance were selected to have unbiased and more accurate results (Cohen et al., 2007). A written consent for the children to participate in the study was provided by the parents. A demographic and health information was collected about the participants from the parents, caregivers and kindergarten teachers. The inclusion criteria included: monolingual BK Kurdish-speaking children aged three to five years with parents speaking BK as their first language, had no developmental delays and no difficulties with their hearing, visual abilities, speech or other language related issues.

2.2. *Procedures and stimuli*

A single-word sampling instrument, the Bahdini Kurdish Articulation Test (BKAT) was used in this study (Ahmed & Hasan, 2022). BKAT is a reliable and valid tool for the evaluation of speech sounds in BK speaking children aged 3-5 years old. The test was a picture naming task of 85 stimulus words that represent all the consonants in initial, medial and final word positions (except p^h, t^h, k^h, ʃ^h, ʈ because of their limited occurrences) and the vowels in word medial position only (because of their restricted distribution). The pictures are familiar to young children and culturally appropriate. The test was presented to 65 normal (38 males and 27 females) Bahdini Kurdish-speaking children. The test was evaluated by experts in phonetics and phonology who approves its validity to measure the articulation capabilities of the children. The content validity of the test was measured in its application to the children and it was found that there is a significant and high correlation between correct word utterances and picture identification. The test is adopted to ensure that virtually all possible phonemes and phoneme combinations are tested. Such tests are used extensively to quantify and evaluate the children's phonological abilities in many languages (for Danish by Clausen & Fox-Boyer, 2017).

The participants were tested individually for 10-20 minutes in a quiet room in their kindergarten and caregiver centers. The test was presented to the children and their responses were audio recorded using a phone voice recorder application. In most cases, familiar people remained in the room where they were asked to stay without any attempts to help the child to say the intended word. The examiner would ask 'What is this?' and the child would reply by naming the picture. However, in the cases, where the subjects did not name the picture spontaneously or correctly, some additional cues or hints were provided including some other questions and showing the real object of a particular pictured word that can be found in that particular place or showing other similar items.

2.3. *Data analysis and measurements*

Children's speech samples were listened to and transcribed narrowly using the conventions of the International Phonetic Alphabet (IPA) by the second author, a native BK speaker and a linguist. The recorded speech samples of 11 children (20% of the data) were randomly selected and independently transcribed by the first author, also a native BK speaker and



a linguist to get the inter-rater reliability. The results showed that the mean percentage of agreement between the two transcribers was (98%). The discrepancies between the two transcriptions were resolved through discussion.

Then, the speech production was analyzed to document the phonological accuracy and whole-word abilities. For phonological accuracy, the measurements of PCC, PVC and PPC were obtained as follow:

- 1- PCC was obtained by dividing the number of correct consonants by the total number of consonants in the sample multiplied by 100.
- 2- PVC was calculated by the percentage of accurate vowels divided by the total number of vowels in the sample multiplied by 100.
- 3- PPC was measured by dividing the number of correct consonants and vowels by the total number of consonants and vowels in the sample multiplied by 100.

The children whole-word abilities are measured using PMLU, PWP, PWC, as follow:

- 1- $PMLU_{target}$, for each target word, the number of segments (consonants and vowels) was counted and summed with the number of consonants in a word,
- 2- $PMLU_{child}$ for the child production, the number of segments is summed with the number of correct consonants produced.
- 3- PWP is derived by dividing the ratio of the child produced $PMLU_{child}$ to the targeted word $PMLU_{target}$
- 4- PWC is calculated by the total number of words that the child produces correctly divided by the total number of words in the sample.

The number of phonemes in the target speech sample is 388 (242 consonants and 146 vowels). The target PMLU is 7.412.

To compare the performance among age groups and genders with regard to the phonological measurements, mean scores were calculated. The statistical tests of Kruskal-Wallis H test is used to compare means scores of age, Post-Hoc Dunn's test is performed for multiple comparisons of age groups and one-tailed t test are used to compare mean scores according to gender.

3. Findings

3.1. Phonological accuracy

The mean values of the phonological accuracy metrics PCC, PVC and PPC of the BK-speaking children by age is shown in Table 4. The older children performed more accurately than the younger on all phonological accuracy measures, however, the difference in the PVC across the ages is not high.

Table 4

PCC, PVC and PPC mean correct percentages and SD by age group

Age group	PCC	PVC	PPC
	Mean % (SD)	Mean % (SD)	Mean % (SD)
36-47 (n=18)	84.02 (6.93)	96.28 (1.85)	90.67 (4.82)
48-59 (n=18)	91.28 (5.89)	96.29 (1.36)	94.72 (3.84)
60-71 (n= 18)	92.78 (2.72)	96.49 (1.38)	95.58 (1.65)
Whole groups	89.36 (4.68)	96.35 (0.11)	93.66 (2.61)

The table shows the mean PCC for age 3-5 children is 89.36 and that of PVC and PPC are 96.35 and 93.66 respectively.

3.2. Whole-word abilities

The mean scores of the whole-word abilities measures PMLU, PWP and PWC of the BK-speaking children by age are presented in Table 5. The results show an increase in the values of PMLU, PWP and PWC as the age increases.

Table 5

Mean vales (SD) of PMLU, PWP and PWC by age group

Age groups	PMLU	PWP	PWC
	Mean (SD)	Mean (SD)	Mean (SD)
36-47 (n=18)	6.77 (0.37)	0.89 (0.09)	0.56 (0.16)
48-59 (n=18)	7.07 (0.18)	0.95 (0.02)	0.76 (0.11)
60-71 (n=18)	7.12 (0.13)	0.95 (0.01)	0.80 (0.07)
Whole groups	6.99 (0.18)	0.93 (0.03)	0.71 (0.12)

The table shows that the mean PMLU for age 3-5 children is 6.99, PWP is 0.93 and PWC is 0.71. There is an increase in the PMLU, PWP and PWC values by age, however PWP in age 4 and 5 has the same mean score.

3.3. Age

To examine whether the differences in the measures of phonological accuracy and whole-word abilities across age groups are significant, we performed the test of Kruskal-Wallis H to show whether the difference is significant and the Post-Hoc Dunn's test using a Bonferroni corrected alpha of 0.017 was performed to examine whether the difference was significant across successive age groups.

For phonological accuracy measures, the results of the Kruskal-Wallis H test show significant differences in the PCC ($X^2=16.98$, $p<.001$) and PPC ($X^2=13.43$, $p<.001$) measures but not in the PVC ($X^2=0.34$, $p=.844$). The result is significant at $p<.05$. The results of Post-Hoc Dunn's test, generally, show that the mean ranks of PCC and PPC are significant between age group 3 & 4 and 3 & 5, but not between the age group 4 & 5. While mean ranks of PVC is not significantly different across all successive age groups, as it is shown in Table 6.



Table 6
 Mean PPC, PVC and PCC scores across successive age groups

Metrics	Age groups	Mean Rank difference	Z	P-value
PCC	3 & 4	-17.9167	3.4172	0.0006328
	3 & 5	-19.4167	3.7032	0.0002129
	4 & 5	-1.5	0.2861	0.7748
PVC	3 & 4	1.5278	0.2915	0.7707
	3 & 5	-1.5278	0.2915	0.7707
	4 & 5	-3.0556	0.5829	0.56
PPC	3 & 4	-16.2778	3.1054	0.001901
	3 & 5	-16.9722	3.2378	0.001204
	4 & 5	-0.6944	0.1325	0.8946

As for whole-word abilities measures, the results of the Kruskal-Wallis H test show that difference in all values between all age groups is significant (for PMLU, $X^2= 15.04$, $p<.001$), for PWP $X^2= 14.11$, $p<.001$, for PWC, $X^2= 19.26$, $p<.001$). The result is significant at $p<.05$. The results of the Post-Hoc Dunn’s test show that the mean ranks of PMLU, PWP and PWC are significant between age group 3 & 4 and 3 & 5, but they are not significant between the age group 4 & 5, as it is indicated in Table 7.

Table 7
 Mean PMLU, PWP and PWC scores across successive age groups

Metrics	Age groups	Mean Rank difference	Z	P-value
PMLU	3 & 4	-16.4167	3.1332	0.001729
	3 & 5	-18.5833	3.5467	0.0003901
	4 & 5	-2.1667	0.4135	0.6792
PWP	3 & 4	-16	3.0805	0.002066
	3 & 5	-17.6667	3.4014	0.0006704
	4 & 5	-1.6667	0.3209	0.7483
PWC	3 & 4	-18.1111	3.4589	0.0005423
	3 & 5	-21.3056	4.069	0.00004721
	4 & 5	-3.1944	0.6101	0.5418

3.4. Gender

This section examines the gender differences in the values of the phonological accuracy and whole-word abilities scores. We performed the one-tailed t test to show whether the difference is significant or not.

For phonological accuracy measures, the male participants have higher mean rates of PCC and PPC, while in PVC the females scored slightly higher. Table 8 shows the measurement of PCC, PVC and PPC for all the participants with regard to gender.

Table 8
PCC, PVC and PPC mean percentages of each age group by gender

Age groups	Gender	PCC	PVC	PPC
		Mean % (SD)	Mean % (SD)	Mean % (SD)
36-47 (n=18)	Male (10)	84.89 (8.42)	96.12 (2.09)	91.28 (6.03)
	Female (8)	82.92 (4.78)	96.48 (1.61)	89.91 (2.92)
48-59 (n=18)	Male (9)	93.02 (3.63)	96.66 (1.48)	95.87 (2.12)
	Female (9)	89.53 (7.33)	95.93 (1.21)	93.56 (4.88)
60-71 (n=18)	Male (11)	92.89 (3.37)	96.21 (1.52)	95.48 (1.96)
	Female (7)	92.61 (1.40)	96.92 (1.11)	95.74 (1.12)
Whole groups	Male (30)	90.27 (4.65)	96.33 (0.29)	94.21 (2.54)
	Female (24)	88.35 (4.95)	96.44 (0.49)	93.07 (2.94)

The table shows that there are differences in the performance of males and females, however, the results of the one-tailed t test showed no significant differences in the comparison of the males and females in all measures across age groups (for PCC $t=-1.12573$, $p=.132724$; PVC $t=0.19774$, $p=.422011$; PPC $t=-1.10583$, $p=.136994$). The result is significant at $p<.05$.

Regarding the whole-word abilities measures, the general results of the whole groups show that females are better than males in the measures of PMLU, PWP, but males are better in PWC. Table 9 presents the mean scores of these measures across gender.

Table 9
The mean scores and SD of PMLU, PWP and PWC of each age group by gender

Age groups	Gender	PMLU	PWP	PWC
		Mean (SD)	Mean (SD)	Mean (SD)
36-47 (n=18)	Male (10)	6.71 (0.45)	0.87 (0.11)	0.58 (0.21)
	Female (8)	6.85 (0.24)	0.92 (0.03)	0.54 (0.1)
48-59 (n=18)	Male (9)	7.11 (0.13)	0.95 (0.01)	0.8 (0.08)
	Female (9)	7.03 (0.21)	0.94 (0.02)	0.73 (0.14)
60-71 (n=18)	Male (11)	7.11 (0.17)	0.95 (0.02)	0.79 (0.09)
	Female (7)	7.13 (0.05)	0.96 (0)	0.81 (0.04)
Whole groups	Male (30)	6.98 (0.22)	0.92 (0.04)	0.72 (0.12)
	Female (24)	7 (0.14)	0.94 (0.01)	0.69 (0.13)

The table shows that there are differences in the performances of males and females in all the measures. However, the results of the one-tailed t test showed no significant differences in the comparison of all the measures in the males and females in all age groups (for PMLU $t=0.25727$, $p=.398995$, for PWP $t=0.83238$, $p=.2045$, for PWC $t=-0.78138$, $p=.21906$).



4. Discussion

This study analysed the phonological development in BK-speaking typically developing children aged 3-5 years using segmental and whole-word measures. The mean score of segmental phonological accuracy measures for 3-5 years BK-speaking children for PCC is 89.36, for PVC 96.35 and for PPC 93.66. The whole-word skills mean score measures for PMLU is 6.99, for PWP 0.93 and for PWC 0.71. There is a significant effect of age on the scores of these measures (except PVC), while no gender effect is observed.

The phonological development in BK seems slightly later than that of other languages. BK has low rates of phonological accuracy measures in comparison to other languages. McLeod and Crowe (2018) in their review of studies on 27 languages stated that by age 5 children produced at least 93% of consonants correctly (PCC), an average PVC of 98.02% and PPC of 96.92. In British English, the mean scores of PCC, PVC and PPC for 3-6:11 normally developing children are 90.81, 98.72 and 93.63 respectively (Dodd et al., 2003). For Danish, the mean scores of PCC and PVC for children aged 2:6-4:11 range from 85.89-98.54 and 93.07-98.84 respectively (Clausen & Fox-Boyer, 2017). In Mukryani dialect of Kurdish, the mean percentage of correct consonant production of children aged 5 was 93.9% (Fatemi-Syadar et al, 2018) and in another study the mean percentages of PCC, PVC and PPC of 3-5 aged children were 91.22, 98.86 and 94.17 respectively (Fatemi-Syadar et al, 2021). The difference can be due that the phonology of BK is acquired later than that of other dialects of Kurdish and other languages as by age 5 the BK children have not fully mastered a number of consonants and the phonological processes are still prevalent (Ahmed, 2023). In addition, the PCC low values might be that BK does contain consonants which have been described as being late acquired speech sounds such as affricates and voiced fricatives (see Dodd et al, 2003; Fox, 2006). The less accurate vowel production might be due to the vowel system of BK which is characterized by vowel qualities that are very close to each other, thus poses a challenge for young children and hard to learn. This claim is supported by Clausen and Fox-Boyer (2017) for Danish who also reported low PVC for Danish in comparison to other languages.

Similarly, BK has low whole-word measures in comparison to other languages. PMLU reflect the phonological structure and complexity of utterances which is language-specific. Different languages have varying phonological structures including differences in the number and types of phonemes, syllable structures and the rules for combining sounds. Besides, they vary in the complexity of their word structures, i.e. some languages allow complex consonant cluster while others do not. This affects the potential maximum PMLU in different languages. BK has a relatively low complex syllable structure and low number of complex consonant clusters in the onset and coda (Hasan, 2024). The longest words in the sample has a target PMLU of 13 in <pirteqal, pelatînk> /pirtaqal, pala:ti:nk/ 'orange, butterfly', the shortest words <şe, av> /se:, a:v/ 'three, water' have a target PMLU of 3 and the mean is 7.412. Thus, BK has a relatively low PMLU in comparison to other languages due to its phonological structure and complexity of the utterances. As for proximity, the rates of whole-word proximity are very low in BK in comparison to other languages. In American

English, in typically developing 36 months old children the PWC reaches 94% (Watson & Terrel, 2012). Additionally, the PWP in 48 to 60 months old Persian-speaking children with Isfahani accents was 0.99 (Karimian et al, 2022). This suggests that BK speaking children pronunciation is close to the adult target, but still not identical because of the segments' incorrectness. Also PWC rates are very low 0.71 in comparison to other languages (for Instance in Jordanian Arabic typically developing children age 5 and the rates were 92-94 (Huneety et al., 2024)). This shows that the BK children cannot produce all the words correctly due to the high rate of phonological errors they produce in their speech. Thus, it can be deduced that BK speaking children are late in the acquisition of segments and in their whole-word phonological abilities.

Age is a crucial factor in the progress of typically developing children (Huneety et al., 2024). The results show that the older children have significantly higher scores in segmental and whole-word abilities phonological metrics, except for PVC, than the younger groups. This suggests that children's phonological system is in progress and that speech errors might need some time to be suppressed. The results also revealed that there is a high significant difference between age groups 3 & 4 and 3 & 5 suggesting rapid growth in the phonological development in 3-4 year old typically developing children in comparison to age group 4-5. Huneety et al (2024) for Jordanian Arabic, Dodd et al. (2003) for British English also indicate that phonological skills develop with age, so older children have more accurate speech and fewer error patterns in their speech. This result is also supported by Ahmed (2023) in her analysis of the phonological processes in BK in that children's use of phonological processes declines gradually as they grow older because as children get older they master those sounds they found to be challenging at first and as a result their pronunciation gets better which leads to less sound errors in their speech. The acquisition of vowels is assumed to be complete before the age of three in BK (Ahmed, 2023), however, the results of this study indicate that the acquisition of the vowels continues after the age of three. Ahmed (2023) analysed vowel production in monosyllabic words and the children fully mastered all the vowels before age 3. In this study, it seems that the children have mastered the vowels, but they have difficulties in producing them in long and more complex words as they undergo deletions and substitutions because of the context. These difficulties seem not to be resolved in the age span under study. Similarly, James (2001) argued that the acquisition of vowels continues after the age of three and Allen and Hawkins (1980) found that children mastered vowels in stressed syllables by 3 years of age but did not master vowels in unstressed syllables until they were 4-5-years-old.

The study showed that gender had no influence on the accuracy and whole-word phonological measures of any age group. There are differences between males and females in some metrics, but the difference is not significant. The influence of gender on phonological development is inconclusive. The findings of this study support those of Zarifian and Fotuhi (2020) for Persian and Fox (2006) for German-speaking children, Maphalala et al (2014) for Xhosa-speaking children and Clausen and Fox-Boyer (2017) for Danish that also did not show any significant difference between females



and males. Amayreh and Dyson (1998) found no significant differences between the performance of females and males, but generally reported better performance of females than males. The results of this study are not in alignment with those of Phoon et al. (2014) investigating Malay and Dodd et al. (2003) investigating English, which found that females performed better than males in the older age groups.

These metrics are often used together to provide a comprehensive picture of a child's phonological development and to identify specific areas where they need more support. They can be used to track progress over time or to compare development across different children. This study is limited to BK. Phonological development can vary significantly across dialects and regions, therefore comparing phonological development in BK with other Kurdish dialects could highlight universal versus language-specific patterns.

5. Conclusion

The study investigated phonological development in typically developing BK speaking children age 3-5 using segmental and whole-word measures. The results of the study have important implications for educators and speech therapists working with Kurdish-speaking children. Understanding the typical phonological development in Kurdish can help in the early identification of speech and language disorders. This knowledge can inform the development of teaching materials and intervention strategies that are culturally and linguistically appropriate. Additionally, the findings underscore the need for further research on Kurdish phonology particularly in the context of its dialectal diversity, speech disorder and the multilingual environments in which the Kurdish children are raised.

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