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Research Article

Icelandic Children's Acquisition of Consonants and Consonant Clusters

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Purpose: This study investigated Icelandic-speaking children's acquisition of singleton consonants and consonant clusters.
Method: Participants were 437 typically developing children aged 2;6–7;11 (years;months) acquiring Icelandic as their first language. Single-word speech samples of the 47 single consonants and 45 consonant clusters were collected using Málhljóðapróf ÞM (ÞM's Test of Speech Sound Disorders).
Results: Percentage of consonants correct for children aged 2;6–2;11 was 73.12 (*SD* = 13.33) and increased to 98.55 (*SD* = 3.24) for children aged 7;0–7;11. Overall, singleton consonants were more likely to be accurate than consonant clusters. The earliest consonants to be acquired were /m, n, p, t, j, h/ in word-initial position and /f, l/ within words. The last consonants to be acquired were /x, r, r̥, s, θ, n̥/, and consonant clusters in word-initial /sv-, stl-, str-, skr-, θr-/, within-word /-ðr-, -tl-/, and word-final /-kl̥, -xt/ contexts. Within-word phonemes were more often accurate than those in word-initial position, with word-final position the least accurate. Accuracy of production was significantly related to increasing age, but not sex.
Conclusions: This is the first comprehensive study of consonants and consonant cluster acquisition by typically developing Icelandic-speaking children. The findings align with trends for other Germanic languages; however, there are notable language-specific differences of clinical importance.

The ability to produce consonants clearly and correctly is a key component of developing intelligible speech and one of the primary markers of speech acquisition. A knowledge of the milestones of typical consonant acquisition in the language/s used by a child is important for understanding typical speech acquisition and for determining when atypical acquisition occurs (McLeod & Crowe, 2018). For speech-language pathologists (SLPs), this information is beneficial for conducting assessments, determining diagnoses, planning intervention, and measuring outcomes for children who may have difficulties during their speech development.

While there are a vast number of languages spoken in the world, a number estimated to exceed 7,000 languages (Eberhard et al., 2020), normative data on typical speech acquisition are available for relatively few. In a systematic review of the age of consonant acquisition across languages, McLeod and Crowe (2018) identified usable data describing consonant acquisition of only 27 languages across 64 studies. These researchers described speech acquisition based on relational analyses, whereby children's productions were compared with the adult target in the ambient language, specifically age of acquisition data for consonants and percentage of consonants correct (PCC). They indicated that the majority of the consonants across the 27 languages were acquired by age 5;0 (years;months) and, at this age, children produced more than 93% of consonants correctly. Place and manner of articulation influenced production, with anterior trills, fricatives, and affricates acquired later in children's development. The following Germanic languages were included in their review: Afrikaans, Danish, Dutch, English, German, and Icelandic. The study of Icelandic included in the review of McLeod and Crowe (2018) described 28 Icelandic-speaking children aged 2;4–3;6 (Másdóttir & Stokes, 2016).

Factors Related to Children's Speech Acquisition

Children's age and sex have been investigated to determine their relationship to speech sound acquisition across many studies in a range of languages, although most studies have focused on English (McLeod & Crowe, 2018).

Age

Overall physical maturation correlates with the acquisition of speech, in that there is a direct correlation between

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age and development of articulation (e.g., McLeod & Crowe, 2018). According to Másdóttir (2008), 3-year-old Icelandic-speaking children have acquired approximately 70% of singleton consonants (75% acquisition criterion). By the ages of 4 and 5 years, the majority of Icelandic consonants have been acquired (Gíslason et al., 1986; Gunnarsdóttir, 1994). Similar findings have been reported for other Germanic languages such as Dutch (Beers, 1995), Danish (Clausen & Fox-Boyer, 2017), and German (Fox & Dodd, 1999). Although English-speaking children begin their speech acquisition at a similar rate, mastery of all consonants (90% criterion) extends to 6 years of age on average (Crowe & McLeod, 2020; McLeod & Crowe, 2018), but longer in some studies (e.g., Smit et al., 1990).

Sex

Sex differences in phonological development seem to be minimal, although studies have been inconclusive. Some studies report on sex effect, in favor of girls showing earlier acquisition (e.g., Dodd et al., 2003; Smit et al., 1990; To et al., 2013), whereas others have found no significant sex difference (e.g., Fox-Boyer, 2016; McIntosh & Dodd, 2008; Phạm & McLeod, 2019; So & Dodd, 1995). However, sex is frequently reported as a factor in speech sound disorders (SSDs), with boys more likely to be identified than girls (McLeod et al., 2013; Shriberg & Kwiatkowski, 1994; Wren et al., 2016). To date, there have been no studies of the influence of age and sex on Icelandic children's speech acquisition.

The Phonology of Icelandic

Icelandic is the national language of Iceland, a country with a population of 350,000 people (Statistics Iceland, 2019). Icelandic is a Germanic language that has similarities with other Nordic languages that grew from Old Norse, that is, Danish, Norwegian, Swedish, and Faroese (Árnason, 2011). Despite having similar roots to other Nordic and Germanic languages, Icelandic has phonological variations that are different from other Nordic languages and most Germanic languages. These differences relate to voicing as well as the length of vowels and consonants in syllables, which are described below. Icelandic has minimal dialectal influences related to phonology.

Consonants

The Icelandic phonological system comprises 25 consonants (Árnason, 2005), which are distributed differently across different word positions, although not all of the consonants are used in a contrastive manner as singleton phonemes (Másdóttir, 2008). There are 22 word-initial consonants in Icelandic (word onset, syllable onset): /pʰ, p, tʰ, t, c , c, kʰ, k, m, n̥, n, θ, f, v, s, ç, h, j, l̥, l, r̥, r/ (Másdóttir & Stokes, 2016), 14 within-word consonants (syllable onset or ambisyllabicity): /p, t, c, k, m, n, ð, f, v, s, ɣ, j, l, r/, and 11 word-final consonants (coda): /p, t, k, m, n, θ, f, s, x, l̥, r̥/ (see Table 1). Phonetically, /r/ is described as a trilled rhotic in Icelandic; however, the flap [ɾ] and the approximant [ɹ] are not contrastive in the language (Árnason, 2005) and are therefore accepted as appropriate variations of the trilled rhotic. Icelandic has 17 voiceless phonemes/allophones and only eight voiced phonemes/allophones.

There are four features of the phonetic and phonemic repertoire of Icelandic that set it apart from the Nordic and Germanic languages. First, Icelandic uses a range of voiceless sonorants /m̥, n̥, ŋ̊, ɲ̊, l̥, r /, which are rare in the world's languages, according to the UCLA Phonological Segment Inventory Database (UPSID-92 as described in Clements, 2003). Some of these sonorants are contrastive in word-initial position, for example, /n/ versus /n̥/, /l/ versus /l̥/, and /r/ versus /r̥/. Second, there are no voiced plosives in Icelandic, and aspiration is contrastive for plosives, for example, /pʰ/ versus /p/, /tʰ/ versus /t/, /cʰ/ versus /c/, /kʰ/ versus /k/. Third, [x] and [ð] are in complementary distribution with /ɣ/ and /θ/, respectively. Finally, there is pre-aspiration of plosives, which can be seen in within-word and word-final positions.

Consonant Clusters

The syllable structure and phonotactic constraints of Icelandic are largely similar to those of English. However, Icelandic can have up to four consonants preceding a vowel and five consonants following a vowel, for example, *strjáll* [strjautl̥] "scattered" or *vermsl* [vɛrmstl̥] "hot spring." There are approximately 70 initial consonant clusters, 289 within-word clusters, and 172 final clusters in Icelandic (Thráinsson & Gíslason, 1993). The prominence of within-word and word-final clusters in Icelandic is due to their role in Icelandic inflectional morphology and agglutinative derivational morphology leading to a high prevalence of multisyllabic words (Másdóttir, 2008). From a very young age, Icelandic children use phonologically complex words in Icelandic and are also able to create and use new phonologically complex words. For example, a child at age 2;4 was recorded to say *tígrisdýragleraugu* [tʰikrɪsti:raklɛ:rœiɣʏ] "tiger glasses" and another at age 3;4 said *sjóræningjatannbursti* [sjou:rainiɲcatʰan:pʏrstɪ] "pirate toothbrush" (Másdóttir, 2008).

Vowels and Diphthongs

Eight vowels /a, ɛ, ɪ, i, ɔ, ʏ, u, œ/ and five diphthongs /ai, ei, ou, œi, au/ are contrastive in Icelandic (Árnason, 2005), and each can be long or short. The general rule of segment length or duration in Icelandic is that vowels are long before single consonants and short before two or more consonants.

Syllables and Segments

The length of segments (vowels and consonants) within a syllable plays an important role in determining syllable length in Icelandic and is a contrastive aspect of the phonological system. Both vowels and consonants may be long or short. Vowels are long in open syllables (e.g., *frá* [frauː] "from," *gefa* [cɛː.va] "to give") and before singleton word-final consonants (e.g., *hús* [huːs] "house"). Otherwise vowels are short and unstressed (e.g., *torg* [tɔrk] "town square," *hestur* [hɛs.tʏr̥] "horse"). The distribution of segments of different lengths, both vowel and consonant length, is complementary. Short vowels occur before long

Table 1. The Icelandic consonant system, based on Árnason (2005) and Másdóttir and Stokes (2016).[a]

Manner	Voice	Place						
		Labial	**Labio-dental**	**Dental**	**Alveolar[b]**	**Palatal**	**Velar**	**Glottal**
Plosives	aspirated	pʰ			tʰ	(cʰ)	kʰ	
	nonaspirated	p			t	(c)	k	
Fricatives	voiceless		f	θ	s	ç	(x)	h
	voiced		v	ð		j	ɣ	
Nasals	voiceless				n̥			
	voiced	m			n			
Laterals	voiceless				l̥			
	voiced				l			
Trill	voiceless				r̥			
	voiced				r			

[a]Consonants in parentheses have traditionally been classified as Icelandic phonemes (Árnason, 2005); however, these consonants are rarely contrastive and thus are allophones. [b]While transcribed as /tʰ/ and /t/, these are realized in dento-alveolar place of articulation in Icelandic.

consonants, and long vowels occur before short consonants (Másdóttir, 2018). Segment length is contrastive for many phonemes in Icelandic, as exemplified in the pair *kisa* [cɪː.sa] "cat" versus *kyssa* [cɪ.sːa] "to kiss." The phonological contrast relating to segment length is among the first that Icelandic children acquire (Másdóttir, 2008).

Disyllabic words are more common in the Icelandic than monosyllabic words. This is to some extent due to the inflectional system, with most word classes having grammatical suffixes, such as penn*i* (singular, nominative, masculine) "pen," kon*a* (singular, nominative, feminine) "woman," penn*ar* (plural, nominative) "pens," and kon*ur* (plural, nominative) "women." Even monosyllabic words frequently become disyllabic or polysyllabic with grammatical suffixes. For instance, *fugl* "bird" becomes fugl*inn* with the definite article "the bird", and fugl*arnir* in plural with the definite article "the birds".

Syllabification is important, considering that units larger than segments (such as syllables and words) are prevalent at early stages in language development. Main lexical stress almost always falls on the first syllable, making syllabification clear. More often than not, consonants are onsets rather than codas (Árnason, 2005; Gussenhoven & Jacobs, 2005). However, syllabification is complex in Icelandic due to ambisyllabicity, which refers to a medial consonant simultaneously belonging to two syllables (Gussenhoven & Jacobs, 2005), for example, *amma* [am.ma] "grandmother." Ambisyllabic words, or geminates, are common in the Icelandic language.

Previous Studies of Icelandic Phonological Development

To date, four studies have focused on typical speech acquisition of Icelandic-speaking children. First, Gíslason et al. (1986) studied 200 Icelandic-speaking children longitudinally, at 4 then 6 years of age, with the aim of investigating children's articulation and ability to generate plurals. A study-specific list of target words was used (see Gíslason et al., 1986, p. 40). All singleton consonants in Icelandic were examined in this study, with the exception of word-initial and -final /θ/ (ages 4 and 6 years) and word-medial /ɣ/ (age 4 years). Children in this study produced 90% of singleton consonants correctly at 4 years of age and 97% accurately at 6 years of age. Gíslason et al. also described the proportion of children who used substitutions, deletions, insertions, and other phonological mismatches for singleton consonants and consonant clusters. The work of Gíslason et al. provides an initial insight in the acquisition of Icelandic consonants that now can be extended by adding a greater age range of participants, providing information about /θ/ (ages 4 and 6 years) and /ɣ/ (age 4 years), conducting statistical analyses of the data, and providing recommendations for SLPs' practice.

Second, Konráðsson (1983) reanalyzed some of the data from Gíslason (1986) to document the acquisition of /s-/ and /r-/ consonant clusters for ninety-two 4-year-old children. He found that, in /s/ consonant clusters, the most common mismatches were deletion of the initial consonant in the cluster and substitutions (distorted sibilants). Interestingly, Konráðsson reported that, for /s/ clusters, /stl/ frequently became /skl/, showing backing of alveolar/dental stops, which was not a common pattern in the Gíslason et al. data. For clusters containing /r/, deletion of the second consonant in the cluster (/r/) occurred. The most common mismatches were substitution of /ð/ for /r/. Konráðsson therefore concluded that /r/ and /s/ behave similarly as singleton consonants and in consonant clusters because of the similar substitution patterns he identified in these clusters.

Third, Gunnarsdóttir (1994) collected data from 496 children aged 4;0–8;11 to establish norms for Magnúsdóttir and Thráinsson's (1981) articulation test. In the test, singleton consonants and consonant clusters were elicited in all three word positions, although the word positions were not separated in either the analysis or the reporting of results. The main results revealed that children gradually increased accuracy in segment production with increasing age, from 97.5% for children aged 4;0–4;5 to almost 100% for children aged 8;0–8;11. All children in the sample were monolingual Icelandic speakers and were excluded if they had history of speech and language "remediation," history of otitis media, current or prolonged hearing loss, history of cleft lip/palate, and/or if their teachers had any concerns about a child's speech and language development.

Fourth, recent studies by Másdóttir and colleagues have investigated phonological development in children with typical and atypical acquisition of Icelandic. Másdóttir (2008) examined longitudinal phonological development of singleton consonants by 28 Icelandic-speaking children, at ages 2;4 and 3;4. She demonstrated similarities between the acquisition of Icelandic and other Germanic languages in terms of the acquisition of consonants, error patterns (phonological processes), and the phonemic feature hierarchy of phonological contrasts. For example, the order of acquisition of manner features was nasals, laterals, plosives (stops), approximants, fricatives, and rhotics. Typical language-specific error patterns included debuccalization (or "h-ization") of obstruents and initial consonant deletion that have been regarded as atypical processes in other languages (e.g., English). Furthermore, /θ/ was the most common substitution for /s/ and /r̥/, yet the children in the study had not acquired the interdental fricative contrastively at the second point of data collection. Másdóttir and Stokes (2016) studied the influence of consonant frequency on speech acquisition of Icelandic-speaking children by reexamining data from Másdóttir (2008). They reported that consonant frequency was a strong predictor of consonant accuracy at age 2;4, but the effect was weaker at age 3;4, suggesting that more frequent productions resulted in increased accuracy of speech sounds at a young age. This effect ("frequency-bound practice effect") possibly explains relatively early acquired speech sounds such as /c/, /ð/, /l/, and /r/ of the youngest Icelandic learners, whereas they are relatively late occurring in languages such as Dutch, English, German, and Swedish. Concerning children with atypical phonological development, Másdóttir (2018) examined the phonological systems of three- (n = 14) and four- (n = 13) year-old children with SSDs (also known as protracted phonological development). Másdóttir reported that, for children acquiring Icelandic with SSD, consonant clusters were particularly vulnerable to reduced accuracy in speech production. For example, accuracy of /r/ consonant clusters for children with SSD was far lower than their age- and sex-matched peers at both 3 (SSD = 0.3%, typically developing = 61.0%) and 4 (SSD = 9.8%, typical developing = 72.4%) years of age.

While these studies provide some insight into the phonological development of Icelandic-speaking children, there are a number of limitations that call for further investigation. First, the age range of children examined in prior research is narrow and studies of different age groups are noncomparable due to differences in methodology. Examination of the full range of singleton consonants and consonant clusters is required for an age range that will include emergence of the earliest sounds (i.e., 2;6) and mastery of the latest developing sounds and clusters (i.e., 7;11; Crowe & McLeod, 2020; McLeod & Crowe, 2018). Second, previous studies have not provided data that can be used by SLPs to inform clinical management of children's speech sound production, such as the accuracy of production of each consonant at different ages and criterion levels, and percentage consonants correct (McLeod & Crowe, 2018). Third, the influence of sex on speech acquisition has not previously been investigated for Icelandic children. This study seeks to provide a comprehensive investigation of the consonant and consonant cluster acquisition of Icelandic-speaking children aged 2;6–7;11 in order to enhance comparability with studies of other languages and provide data to support SLPs' decision making regarding assessment, diagnosis, intervention, and discharge for children with SSD. The aims of this study were to (a) examine the accuracy and pattern of acquisition of Icelandic consonants and consonant clusters (i.e., PCC, age of acquisition, and effect of word position) and (b) to explore the effect of age and sex on consonant accuracy. It was hypothesized that (a) the percentage of consonants and consonant clusters correct would be lower for the younger participants in the study and (b) there would be differences in consonant accuracy between groups of participants based on age, but not sex.

Method

Ethical Approval

Approval to conduct this study was provided by Persónuvernd (The Data Protection Authority, Iceland; S5266/2011). Written permission to collect data within Reykjavík was provided by Department of Education and Youth (MSR2011040040/SFS2012630104), and verbal permission was provided by other municipalities. Consent to participate in the project was given by all preschool directors. Written consent was given by all parents of children who participated, and assent was gained from the children themselves.

Participant Recruitment

Preschools and elementary schools located in Reykjavík (and surrounds), Reykjanesbær, Hveragerði, Selfoss, Akranes, and Akureyri (N = 27) were invited to participate in this study. Although the majority of the population of Iceland lives in Reykjavík and surrounding areas, efforts were made to ensure that children from different regions in Iceland were included. As mentioned above, there are minimal differences in dialect in Icelandic and no dialect differences are phonologically contrastive. Teachers were asked to identify every typically developing monolingual Icelandic-speaking child at their preschool/school who was between the ages of 2;6 and 7;11. Children were not included if they had a cleft lip/palate, had been diagnosed with a developmental disorder (e.g., Down syndrome, autism), had a moderate or greater hearing loss (based on parent report), or their parents did not speak Icelandic as their native language. Parental questionnaires were received for 486 children, and assessments were completed for 437 children. Reasons for noninclusion were (a) not at school on day of testing (n = 12), (b) the child was unable to complete the assessment (n = 7), (c) insufficient time to assess during assessment period (n = 28), and (d) the child subsequently was identified as being bilingual (n = 2).

Participants

Participants were 437 children aged between 2;6 and 7;11. Therefore, the sample consisted of 437 children with complete data in the identified preschools and elementary schools, representing 19% of all children in Iceland aged 2–7 years in the identified preschools and elementary schools (cf. Iceland Statistics, 2019). There were 224 boys and 213 girls. Groupings for children between ages 2;6 and 5;11 were based on 6-month intervals as this is when major developmental changes occur within the phonological system (see Table 2). Children aged between 6;0 and 7;11 were divided into only two groups, as these children have generally reached a mastery level of most singleton consonants and consonant clusters. As a society with a strong social safety net, Iceland is considered to be relatively homogenous in terms of the socioeconomic and parental education factors that are considered in studies of speech acquisition (OECD, 2014; Statistics Iceland, 2013, 2018). Furthermore, individualized data regarding socioeconomic status, parents' education level, and parents' occupation have not been commonly reported as factors that impact phonological development (e.g., Dodd et al., 2003; Smit et al., 1990).

Instrument

The Icelandic speech sound test Málhljóðapróf ÞM (ÞM's Test of Speech Sound Disorders [MHP]; Násdóttir, 2014) was used to elicit all singleton consonants of the Icelandic phonological system, as well as a representative sample of consonant clusters that were frequently used by children and frequently the focus in speech-language pathology sessions (Másdóttir, 2008). A total of 96 familiar words were elicited for each child, describing 47 single consonant phonemes and 45 consonant clusters. The test consisted of colored drawings and photos to elicit single words. The MHP is a standardized test for Icelandic-speaking children and is widely used by certified SLPs in Iceland (Másdóttir, 2019). The current study reports on data collected to provide a normative sample for the MHP.

Procedure

Parents of typically developing monolingual Icelandic-speaking children in identified preschools and elementary schools were asked to complete a consent form and a case history questionnaire describing their child's hearing, overall development, cognition, and language skills. The children were tested by two certified and experienced Icelandic-speaking SLPs (including the first author) and six Icelandic-speaking

Table 2. Mean and standard deviation for percentage of consonants correct (PCC), accuracy of singleton consonants, and consonant clusters across word positions, by age and sex.

				Singleton consonants			Consonant clusters		
			PCC	Word-initial	Within-word	Word-final	Word-initial	Within-word	Word-final
Age	Sex	*n*	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
2;6–2;11	Female	14	75.69 (11.12)	74.03 (15.28)	84.69 (7.34)	77.92 (14.14)	33.17 (24.01)	59.02 (25.92)	37.50 (27.30)
	Male	20	71.32 (14.68)	73.64 (18.98)	86.07 (9.96)	78.18 (15.44)	44.75 (34.50)	60.64 (24.18)	35.00 (36.63)
	Total	34	73.12 (13.33)	73.80 (17.30)	85.50 (8.88)	78.07 (14.70)	39.98 (30.75)	59.97 (24.53)	36.03 (32.68)
3;0–3;5	Female	26	79.81 (14.36)	78.32 (19.04)	84.07 (10.75)	79.72 (16.92)	49.89 (31.30)	65.81 (27.25)	25.00 (34.10)
	Male	27	77.47 (14.02)	76.26 (15.96)	85.98 (9.80)	82.15 (14.37)	45.19 (32.29)	64.79 (24.19)	37.50 (31.77)
	Total	53	78.62 (14.10)	77.27 (17.40)	85.04 (10.22)	80.96 (15.57)	47.50 (31.59)	65.29 (25.49)	31.13 (33.22)
3;6–3;11	Female	27	87.76 (10.02)	87.88 (8.36)	89.95 (8.47)	85.19 (13.14)	65.24 (32.05)	77.53 (23.18)	53.70 (37.79)
	Male	33	87.62 (11.04)	90.22 (8.20)	95.02 (6.31)	93.39 (8.28)	79.32 (24.52)	86.70 (15.79)	60.61 (33.67)
	Total	60	87.68 (10.51)	89.17 (8.29)	92.74 (7.72)	89.70 (11.41)	72.98 (28.78)	82.57 (19.83)	57.50 (35.45)
4;0–4;5	Female	28	93.81 (5.86)	91.72 (6.43)	93.62 (6.25)	91.88 (7.96)	75.55 (25.65)	87.01 (15.20)	70.54 (27.26)
	Male	22	88.03 (10.62)	90.08 (10.56)	93.51 (7.28)	92.98 (7.39)	66.96 (31.53)	81.42 (16.76)	59.09 (32.32)
	Total	50	91.26 (8.70)	91.00 (8.44)	93.57 (6.65)	92.36 (7.65)	71.77 (28.41)	84.55 (15.99)	65.50 (29.83)
4;6–4;11	Female	28	96.68 (4.51)	91.23 (8.74)	94.90 (7.98)	92.86 (10.31)	80.95 (27.04)	91.10 (15.65)	72.32 (28.33)
	Male	27	93.73 (7.42)	92.42 (10.62)	95.77 (8.69)	93.27 (11.16)	86.18 (24.07)	92.58 (9.66)	77.78 (24.35)
	Total	55	95.23 (6.24)	91.82 (9.64)	95.32 (8.27)	93.06 (10.64)	83.52 (25.53)	91.82 (12.96)	75.00 (26.35)
5;0–5;5	Female	21	97.03 (4.32)	93.72 (5.47)	97.62 (4.12)	94.37 (9.30)	89.74 (16.42)	91.96 (11.88)	84.52 (21.62)
	Male	23	93.63 (8.14)	91.50 (7.29)	95.34 (5.94)	92.89 (8.65)	78.68 (27.86)	87.23 (17.22)	67.39 (32.36)
	Total	44	95.29 (6.71)	92.56 (6.51)	96.43 (5.22)	93.60 (8.89)	83.96 (23.53)	89.49 (14.94)	75.57 (28.78)
5;6–5;11	Female	23	96.35 (4.39)	94.66 (5.59)	97.52 (4.09)	95.65 (6.05)	88.80 (21.97)	91.58 (13.80)	83.70 (24.55)
	Male	23	95.77 (5.75)	95.85 (5.64)	97.83 (4.54)	96.05 (7.16)	87.46 (23.05)	94.29 (12.20)	76.09 (29.66)
	Total	46	96.05 (5.08)	95.26 (5.58)	97.67 (4.27)	95.85 (6.56)	88.13 (22.28)	92.93 (12.95)	79.89 (27.19)
6;0–6;11	Female	24	98.66 (2.58)	95.27 (5.27)	96.13 (6.65)	95.08 (10.38)	89.03 (22.18)	94.53 (13.20)	81.25 (32.34)
	Male	26	98.25 (2.98)	96.50 (3.71)	98.08 (5.17)	97.90 (5.34)	93.79 (16.25)	94.39 (8.43)	88.46 (23.70)
	Total	50	98.45 (2.77)	95.91 (4.52)	97.14 (5.95)	96.55 (8.19)	91.50 (19.27)	94.46 (10.87)	85.00 (28.12)
7;0–7;11	Female	22	99.58 (0.54)	98.14 (2.29)	100.00 (0.00)	100.00 (0.00)	100.00 (0.00)	98.58 (3.82)	98.86 (5.33)
	Male	23	97.56 (4.32)	97.43 (3.58)	98.14 (3.21)	97.23 (5.08)	95.48 (12.14)	97.28 (9.20)	96.74 (11.44)
	Total	45	98.55 (3.24)	97.78 (3.01)	99.05 (2.46)	98.59 (3.85)	97.69 (8.88)	97.92 (7.05)	97.78 (8.95)

Note. Ages are given as years;months.

master's students in the speech-language pathology program at the University of Iceland. The students received training regarding elicitation methods, scoring, and transcription and were supervised by the two certified SLPs.

The children were tested individually in their schools, in a relatively quiet room. Elicitation was in accordance with the manual for the MHP (Másdóttir, 2014) and similar studies (e.g., Dodd et al., 2003; Goldstein et al., 2004; Hua & Dodd, 2006). The target words were elicited spontaneously. If a child was unable to produce a target word spontaneously, delayed imitation was used, for instance, "Is this (target word) or (distraction word)?" If the child was still unable to produce the target word, direct imitation was used; for example, "Say (target word)." During data collection, errors in children's responses were noted online by assessors and audio recordings were made using either Olympus Digital Voice Recorder WS-811 or a Sony MiniDisc Recorder (MZ-R30) with a multidirectional Sony Condenser Stereo microphone (ECM-DS70P). Online notes and assessment recordings were used by three experienced transcribers (linguists and SLPs) to transcribe each word elicited in full. Data were entered by the first author, and data entry was checked by the third author.

Reliability

The first author checked all recordings and retranscribed 132 (30%) of the data (36,432 data points for consonants). Transcription reliability was conducted by a native Icelandic speaker with a degree in linguistics who is a practicing SLP. The interrater point-to-point reliability was conducted for 45 participants, stratified for 10% in each age group. Interrater reliability was 95.77% (12,420 data points for consonants), which is an adequate level of interrater reliability, according to Shriberg and Lof (1991). Most of the discrepancies involved /s/ distortions, word-initial glottal stops (deletions vs. glottal stops), and the rhotic /r/. Discrepancies were discussed until consensus was reached.

Data Analysis

A child's production was considered to be correct if the child produced the consonant or consonant cluster in a manner expected in the adult production form of the word, as transcribed on the MHP score form (Másdóttir, 2014). Two sets of analyses were undertaken: (a) age of acquisition based on a relational analysis of each target segment (i.e., each singleton consonant and consonant cluster) and (b) calculation of the PCC. Age of acquisition data for each singleton consonant or consonant cluster are reported using 50%, 75%, and 90% criteria in accordance with previous research (Beers, 1995; Clausen & Fox-Boyer, 2017; Fox & Dodd, 1999; Másdóttir & Stokes, 2016; McLeod & Crowe, 2018). Age of acquisition and PCC data were reported for children in 6-month age intervals for the younger participants (ages 2;6–5;11) where rapid age-related changes in accuracy could be anticipated, and in 12-month age intervals for the older participants (ages 6;0–7;11) where changes in accuracy were anticipated to be smaller. All segments were included in order to obtain a PCC score, with one exception. Errors with /r/ were excluded if they occurred as a morphophoneme (these grammatical suffixes occurred in 12 of the 96 target words). It was reasonable to exclude the /r/ suffix because of the influence of morphology on phonological acquisition (Howland et al., 2019). Regarding the classification of within-word consonants, the conventions used in Másdóttir and Stokes (2016) were followed whereby geminates that occur within words were classified as ambisyllabic (medial or within-word), rather than syllable initial.

Data for each participant's age, sex, PCC, and accuracy of singleton consonants and consonant clusters were entered into SPSS Version 26.0 (IBM, 2019). Multivariate regression analysis was conducted to examine the effect of children's age (in months) and sex (male vs. female) on the accuracy of production (PCC, singleton consonants, consonant clusters) to take into consideration the relations among the three dependent variables. Univariate multiple regression analyses were used as post hoc analyses to explore the role of age and sex on each of the three dependent variables. Partial eta squared (η_p^2) was used to calculate effect size.

Results

Accuracy of Production

PCC

The mean and standard deviations for PCC by age and sex are summarized in Table 2. Although the overall total PCC scores demonstrate a gradual increase from lowest to highest age group, there were a few exceptions. Specifically, boys at ages 4;6–4;11 had a slightly higher PCC score than girls at ages 5;0–5;5. Similarly, boys at ages 6;0–6;11 had a slightly higher PCC score than boys in the oldest group (ages 7;0–7;11).

Acquisition of Singleton Consonants

The mean percentages and standard deviations for accuracy of singleton consonants in all word positions, by age and sex, are summarized in Table 2. For word-initial position, overall accuracy of singleton consonant production increased with age, with a relatively rapid increase between ages 3;0–3;5 and 3;6–3;11. Within-word and word-final positions were generally higher in accuracy than word-initial position, with within-word singleton consonants being relatively more accurate than the other two positions, especially in the youngest groups. Table 3 shows singleton consonant acquisition across positions (word-initial, within-word, word-final) by 50%, 75%, and 90% of participants in each age group. Of the 47 singleton consonants represented in word-initial, within word, and/or word-final positions, 79.12% were acquired by ages 2;6–2;11. By age 5;11, most single consonants were acquired except for /s/, /r/, /r̥/ and /n̥/ in initial position, and /s/ in final position, with total accuracy across all three word positions being 96.05%.

Acquisition of Consonant Clusters

The mean accuracy for consonant clusters for all word positions, by age and sex, also is summarized in Table 2. Overall, there was a gradual increase in accuracy across

Table 3. Age of acquisition of singleton consonants in word-initial (WI), within-word (WW), and word-final (WF) positions.

Criterion	Word position	2;6–2;11 *n* = 34	3;0–3;5 *n* = 53	3;6–3;11 *n* = 60	4;0–4;5 *n* = 50	4;6–4;11 *n* = 55	5;0–5;5 *n* = 44	5;6–5;11 *n* = 46	6;0–6;11 *n* = 50	7;0–7;11 *n* = 45
90%	WI	m, n, p, t, j, h	m, n, p, t, j, h, l	m, n, p, pʰ, t, tʰ, c, cʰ, k, kʰ, f, v, ç, j, h, l, l̥	m, n, p, pʰ, t, tʰ, c, cʰ, k, kʰ, f, v, ç, j, h, l	m, n, p, pʰ, t, tʰ, c, cʰ, k, kʰ, f, v, ç, j, h, l, l̥	m, n, p, pʰ, t, tʰ, c, cʰ, k, kʰ, f, v, ç, j, h, l, l̥	m, n, p, pʰ, t, tʰ, c, cʰ, k, kʰ, f, v, θ, ç, j, h, l, l̥	m, n, p, pʰ, t, tʰ, c, cʰ, k, kʰ, f, v, θ, s, ç, j,h, r, r̥, l, l̥	m, n, p, pʰ, t, tʰ, c, cʰ, k, kʰ, f, v, θ, s, ç, j, h, r, r̥, l, l̥
	WW	m, n, p, t, k, f, j, l	m, n, p, t, c, k, f, v, j, l	m, n, p, t, c, k, f, v, j, l	m, n, p, t, c, k, f, v, ð, j, l	m, n, p, t, c, k, f, v, ð, j, l	m, n, p, t, c, k, f, v, ð, j, l	m, n, p, t, c, k, f, v, ð, j, ɣ, r, l	m, n, p, t, c, k, ð, f, v, s, j, ɣ, r, l	m, n, p, t, c, k, f, v, ð, s, j, ɣ, r, l
	WF	m, n, p, t, k, f	m, n, p, t, k, f, l̥	m, n, p, t, k, f, l̥	m, n, p, t, k, f, θ, l̥	m, n, p, t, k, f, l̥	m, n, p, t, k, f, θ, l̥	m, n, p, t, k, f, θ, x, r̥, l̥,	m, n, p, t, k, s, f, θ, x, r̥, l̥	m, n, p, t, k, f, θ, s, x, r̥, l̥
75%	WI	pʰ, c, k, v, f, l	pʰ, tʰ, kʰ, k, c, cʰ, f, v, l̥	—	s, r, r̥, l̥	s, r	θ, s, r, r̥	s, r, r̥	—	—
	WW	c, v, ð	ð	ð	s, r	s, ɣ, r	s, ɣ, r	s	ɣ	—
	WF	l̥	θ	θ	x, r̥	θ, s, x, r̥	s, x, r̥	s	—	—
50%	WI	tʰ, cʰ, kʰ, ç, l̥	ç, r	θ, s, r	θ	θ, r̥	—	n̥	n̥	n̥
	WW	s	s, r	s, ɣ, r	ɣ	—	—	—	—	—
	WF	s, θ	s, r̥	s, x, r̥	s	—	—	—	—	—
< 50%	WI	n̥, θ, s, r, r̥	n̥, θ, s, r̥	n̥	n̥	n̥	n̥	—	—	—
	WW	ɣ, r	ɣ	—	—	—	—	—	—	—
	WF	x, r̥	x	—	—	—	—	—	—	—

Note. Em dashes indicate that no consonants were acquired within this age group.

age groups, especially for word-initial and within-word positions. There was a limited difference in the accuracy of word-initial consonant clusters between age groups 4;6–4;11 and 5;0–5;5, with the younger group displaying slightly higher accuracy scores. The within-word position was consistently more accurate than word-initial position across all age groups for consonant clusters. Word-final consonant clusters were more accurate throughout for ages 5;0–5;11, 5;6–5;11, and 7;0–7;11. Girls aged 3;0–3;5 scored considerably lower than girls at 2;6–2;11 for word-final consonant cluster accuracy, resulting in a higher overall score for the younger age group. Table 4 shows consonant cluster acquisition across word positions (word-initial, within-word, word-final) by 50%, 75%, and 90% of participants in each age group. Of the 45 consonant clusters, only 9% were acquired to 90% criterion and 15.56% to 75% criterion by age 2;6–2;11. By age 5;11, all consonant clusters were acquired to 75% criterion except for /ðr/ within words, with total accuracy across all three word positions being 86.98%.

Effect of Age and Sex on the Accuracy of Production

Multivariate regression analysis with univariate multiple regression analyses as post hoc were conducted to explore the role of children's age and sex on the accuracy of production (PCC, singleton consonants, consonant clusters). An interaction term between children's age and sex was computed and tested in the model; however, this interaction was not statistically significant and therefore removed from further analyses for the purpose of having a parsimonious model.

The results of multivariate regression analysis indicated that there was a significant omnibus effect of children's age on the accuracy of production with a large effect, Wilks' lambda $\Lambda = .61$, $F(3, 428) = 92.60$, $p < .001$, $\eta_p^2 = .39$, and a significant omnibus effect of children's sex on the accuracy of production with a small effect, Wilks' lambda $\Lambda = .96$, $F(3, 428) = 5.42$, $p = .001$, $\eta_p^2 = .04$. Specifically, older children were likely to have higher PCC ($\beta = .59$, $p < .001$), higher singleton consonant accuracy ($\beta = .54$, $p < .001$), and higher consonant cluster accuracy ($\beta = .55$, $p < .001$). Girls scored higher in PCC than boys ($\beta = -.12$, $p = .003$), but there were no significant sex differences for the singleton consonant accuracy ($\beta = .02$, $p = .65$) or consonant cluster accuracy ($\beta = -.01$, $p = .91$). The regression models explained in total 36.6%, 28.3%, and 29.7% of the total variance in PCC, singleton consonants, and consonant clusters, respectively (see Table 5).

Discussion

This is the first study of the acquisition of single consonants and consonant clusters to consider a wide age range of Icelandic-speaking children. PCC for children aged 2;6–2;11 was 73.12 (*SD* = 13.33) and increased for children aged 7;0–7;11 to 98.55 (*SD* = 3.24). Overall, singleton consonants were more likely to be accurate than consonant clusters, and phonemes in within-word position typically were more accurate than those in word-initial position and then word-final position. The earliest consonants to be acquired were /m, n, p, t, j, h/ in word-initial position and /f, l/ within words. The last phonemes to be acquired were the consonants /ɣ, x, r, r̥, s, θ, n̥/, word-initial consonant clusters /sv-, stl-, str-, skr-, θr-/, within-word consonant clusters /-ðr-, -tl-/, and word-final consonant clusters /-kl̥, -xt/. There were statistically significant differences for age for accuracy of singleton consonant and consonant cluster production as well as for PCC. Statistically significant differences for sex were observed only for PCC.

Generally, the developmental trajectories of consonant accuracy increased with age. The increase in total PCC with advancing age most closely resembled the trajectory for singleton consonants in the word-initial position. PCC and singleton consonants (all positions) followed a similar developmental trajectory, rapidly increasing in accuracy from 2;6–2;11 to 4;6–4;11 and then with a more gradual slope toward the oldest participant age group (ages 7;0–7;11). In contrast, the accuracy of consonant clusters (all positions) was well below that of PCC and singleton consonants at ages 2;6–2;11 and experienced periods of both steep and gradual increases in accuracy until ages 7;0–7;11 when a similar level of accuracy as PCC and singleton consonants was reached. The large age range of this study (ages 2;6–7;11) enabled the key stages of Icelandic consonant acquisition to be observed, with children in the oldest age group achieving mastery of singleton consonants and consonant clusters.

The findings of this study align with the cross-linguistic review of singleton consonant acquisition across 64 studies in 27 languages by McLeod and Crowe (2018). McLeod and Crowe reported that by 5 years of age, the majority of children had mastered most consonants in the ambient language and that the average PCC was 93.80. Similarly in Icelandic, by 5 years of age, most consonants were acquired and the mean PCC was 95.29. In Icelandic, as well as in other languages, nasals and plosives were acquired earlier than fricatives. While McLeod and Crowe did not consider consonant clusters, studies of other languages have reported lower accuracy of consonant clusters compared to singleton consonants. For example, in Danish, Clausen and Fox-Boyer (2017) reported that all consonants with the exception of one were acquired by children ages 2;6–2;11, whereas the majority of consonant clusters were not mastered until ages 3;6–3;11. Similar findings on the lag in consonant cluster acquisition have been reported for German (Schaefer & Fox-Boyer, 2016), Dutch (Beers, 1995; Gerrits & Zumach, 2006), and English (McLeod et al., 2001a, 2001b; Yavaş & Core, 2006). As can be seen in Figure 1, the mean accuracy of PCC and singleton consonants generally increased in a linear manner until mastery was achieved. In contrast, the accuracy of consonant clusters alternated between rapid increases, plateaus, and even slight decreases in accuracy (see Figure 1). While these decreases in themselves may not be clinically significant, decreases in mean accuracy of production also has been observed in studies of other languages (Gangji et al., 2015; Kenney & Prather, 1986).

Table 4. Age of acquisition of consonant clusters in word-initial (WI), within-word (WW), and word-final (WF) positions.

Criterion	Word position	2;6–2;11 *n* = 34	3;0–3;5 *n* = 53	3;6–3;11 *n* = 60	4;0–4;5 *n* = 50	4;6–4;11 *n* = 55	5;0–5;5 *n* = 44	5;6–5;11 *n* = 46	6;0–6;11 *n* = 50	7;0–7;11 *n* = 45
90%	WI	pl	pl	pj, pl, pʰl, tʰv	pj, pl, pʰl	pj, pl, pʰl, tʰv, kʰl, sn, sj	pj, pl, pʰl, tʰv, kʰr, kʰl, fl, sn, sp, st, sj	pr, pʰr, tr, tʰr, pj, pl, pʰl, tʰv, kr, kʰr, kl, kʰl, fr, fl	pr, pʰr, tr, tʰr, pj, pl, pʰl, tʰv, kr, kʰr, kl, kʰl, fr, fl, sm, sn, sp, st, sk, sv, sj, stl, str, skr, θr	pr, pʰr, tr, tʰr, pj, pl, pʰl, tʰv, kr, kʰr, kl, kʰl, fr, fl, sm, sp, sk, sv, sj, stl, str, skr, θr
	WW	nt, hpl	hpl	nt, ŋ̊k, hk, hpl	m̥p, nt, ŋ̊k, l̥t, hk, hpl	m̥p, nt, ŋ̊k, tl, sp, st, sk, lt, l̥p, l̥t, l̥k, hk, hpl	m̥p, nt, ŋ̊k, l̥p, l̥t, l̥k, st, sk, lt, hk, hpl	m̥p, nt, ŋ̊k, kl, l̥p, l̥t, l̥k, lt, r̥t, hk, hpl	m̥p, nt, ŋ̊k, tl, kl, l̥p, l̥t, l̥k, lt, sp, st, sk, r̥t, hk, hpl	m̥p, nt, ŋ̊k, tl, kl, l̥p, l̥t, l̥k, lt, sp, st, sk, ðr, r̥t, hk, hpl
	WF	tl̥		mp	mp, tl̥	mp, tl̥	mp	mp, tl̥	mp, tl̥, kl̥, xt	mp, tl̥, kl̥, xt
75%	WI		pʰl, kl, kʰl, pj	kl, kʰl, fl	pr, tʰv, tr, kr, kʰr, kl, kʰl, fr, sj, sl	pr, tr, tʰr, kr, kʰr, kl, fr, fl, sm, sp, st, sk, sv, stl	pr, pʰr, tr, tʰr, kr, kl, fr, fl, sm, sk, sv, stl, str, skr, θr	sm, sn, sp, st, sk, sv, sj, stl, str, skr, θr	—	sn, st
	WW	tl, hk	nt, tl	m̥p, tl	sp, st, sk, r̥t, lt, l̥p, l̥k	kl, r̥t	kl, sp, r̥t	tl, sp, st, sk	ðr	—
	WF	mp	mp, tl̥	tl̥		kl̥	tl̥, kl̥	kl̥, xt	—	—
50%	WI	pj, pr, pʰl, kl, kʰl, sj	pr, tʰv, tr, fl, sj	pr, pʰr, tr, tʰr, kr, kʰr, fr, sm, sn, sp, st, sk, sv, sj, stl	pʰr, tʰr, sm, sn, sp, st, sk, sv, stl, str, skr	pʰr, θr, str, skr	—	—	—	—
	WW	ŋ̊k, kl, st	m̥p, ŋ̊k, kl, lt, l̥p, l̥t, l̥k, hk	kl, sp, st, sk, r̥t, lt, l̥p, l̥t, l̥k	tl, kl	—	tl	ðr	—	—
	WF	kl̥	kl̥	kl̥	kl̥	xt	xt	—	—	—
< 50%	WI	pʰr, tr,t ʰr, tʰv, kr, kʰr, fr, fl, θr, sm, sn, sp, st, sk, sv, stl, str, skr	pʰr, tʰr, kr, kʰr, fr, θr, sm, sn, sp, st, sk, sv, stl, str, skr	θr, str, skr	θr	—	—	—	—	—
	WW	m̥p, ðr, sp, sk, r̥t, lt, l̥p, l̥t, l̥k	ðr, sp, st, sk, r̥t	ðr	ðr	ðr	ðr	—	—	—
	WF	xt	xt	xt	xt	—	—	—	—	—

Note. Em dashes indicate that no clusters were acquired within this age group.

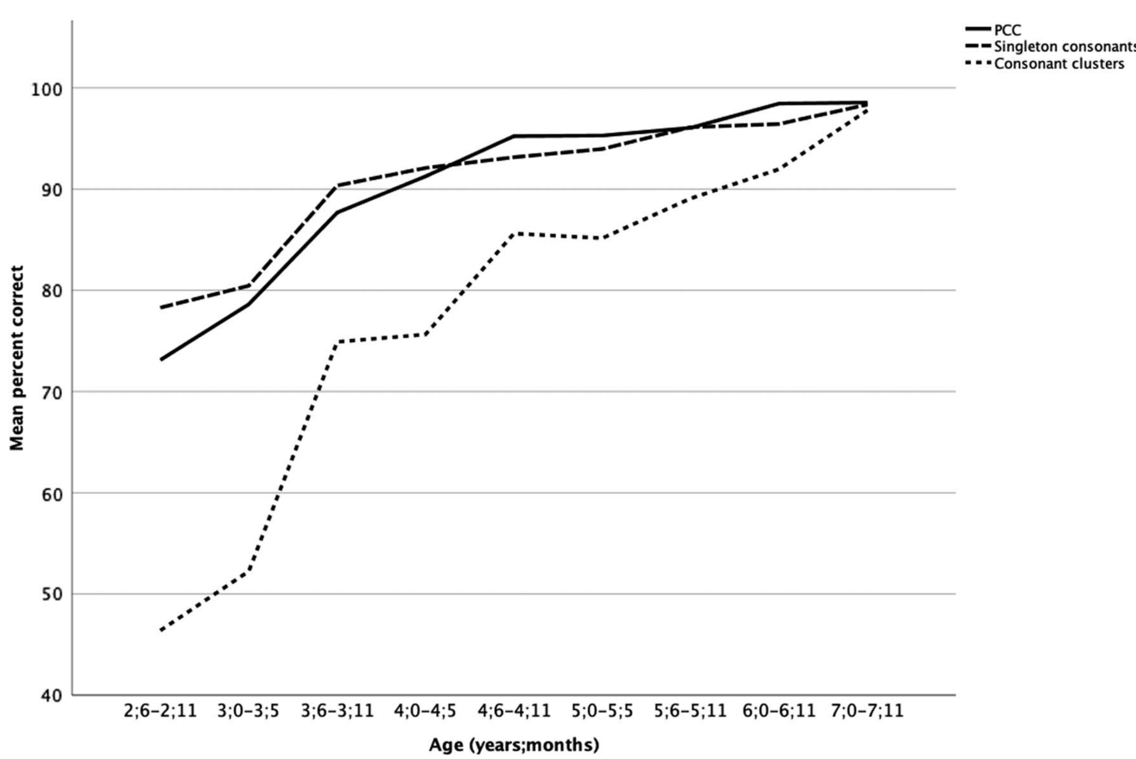
Table 5. Univariate multiple regression exploring the role of age and sex on PCC, singleton consonant accuracy, and consonant cluster accuracy.

Factor	PCC	Singleton consonant	Consonant cluster
Child's age in months	0.59***	0.54***	0.55***
Male	−0.12**	0.02	−0.01
F (2, 430)	125.48***	86.42***	92.27***
Adjusted R^2	0.37	0.28	0.30
η_p^2	0.37	0.29	0.30

Note. All coefficients are standardized β. PCC = percentage of consonants correct.
***$p < .001$. **$p < .01$.

The effect of sex on consonant and consonant cluster acquisition has been inconsistent in studies of a range of languages. Across studies, there have been reports of differences related to sex; however, across studies, these differences are not consistent in whether differences are statistically significant, the age at which differences are found, or the sex who shows an earlier mastery of sounds (Smit et al., 1990; To et al., 2013). The trend across previous research, however, is that females are more often showing advanced skills than males (e.g., To et al., 2013). No previous discussion of the effect of sex on accuracy of consonant cluster acquisition was able to be found in the literature. Therefore, what this study adds to the literature is a finding that differences related to sex were not present for neither singleton consonants nor consonant cluster in Icelandic-speaking children. However, a significant effect for sex was present for PCC. In the current sample, it is likely that the better performance of females for consonant clusters also impacted their better performance for PCC. As PCC scores consider production accuracy for all consonants, accurate production of the consonant cluster /skr-/ would contribute three accurate consonants to the PCC score, whereas production of a singleton consonant contributes only one. This could be an artifact of the design of the test MHP, which focused on representing all phonemes in word-initial, within-word, and word-final positions as well as all clinically relevant clusters (based on Másdóttir, 2008). As MHP was not originally designed to provide PCC data, bias may have occurred in these calculations.

Figure 1. Mean accuracy by age for total percentage of consonants correct, singleton consonants, and consonant clusters. PCC = percentage of consonants correct.



However, the findings on overall PCC align well with those of studies of other languages (see McLeod & Crowe, 2018).

Limitations and Future Research

There are a number of limitations in this study. First, while the overall sample size was comparable for cross-linguistic studies of speech sound acquisition (see McLeod & Crowe, 2018), the wide age range of participants (ages 2;6–7;11) meant that there were less than 100 boys and girls in each age group (see Table 2). Future research could add more Icelandic-speaking participants to the current data set so that subgroups have > 100 participants to increase reliability and reduce variability in standardized tests (McCauley & Swisher, 1984). Second, as this study was cross-sectional, only assumptions can be made about the developmental trajectories of individual children acquiring Icelandic. A future longitudinal study could inform understanding of developmental trajectories as well as factors relating to the effect of sex on speech accuracy. Future research could undertake phonological analyses and describe consonant mismatches, phonological processes, and additional insights into Icelandic consonant features that are more prominent than other Germanic languages (such as voiceless sonorants, e.g., /n̥/), or rarely described in other studies (e.g., preaspiration of stops). This information is currently not known for the Icelandic language and is clinically important to SLPs supporting Icelandic-speaking children. Additional research to finalize the standardization of MHP is ongoing, including phonological process analysis (Benediktsdóttir et al., 2020), test–retest reliability, and sensitivity and specificity data. This information will increase the usefulness of the MHP for SLPs in Iceland and elsewhere in the world when assessing Icelandic-speaking children.

Clinical Implications

The clinical implications of this research are significant. Until now, Icelandic clinicians have not had comprehensive data on consonant and consonant cluster acquisition of Icelandic-speaking children across a broad range of ages. As clinicians strive for evidence-based practice (EBP) in their daily work, the absence of accurate information about consonant acquisition has stymied their ability to consider the best available research evidence as EBP requires (Roulstone, 2011). Furthermore, the lack of a well-designed and rigorous psychometric test to assess Icelandic-speaking children has meant that, to date, conducting research to support EBP has not been possible. The findings of this study make a significant contribution to improving both these situations for SLPs in Iceland. Having data on consonant and consonant cluster acquisition in Icelandic is crucial for SLPs in Iceland who have in the past had to rely on data from Icelandic studies with small samples or on other languages. Historically, English speech acquisition data have been used as a proxy for Icelandic-speaking children due to its availability and long tradition of research. An important clinical finding of this study relates to the differences in the age of acquisition of consonants that co-occur in Icelandic and English. For example, in American English, /l/ is acquired (90% criterion) at an average age of 4;5 (M = 53.75 months, SD = 10.43; Crowe & McLeod, 2020) whereas /l-/ in Icelandic is acquired earlier, being acquired (90% criterion) at ages 3;0–3;5 in word-initial position and at ages 2;6–2;11 within words. Another reason for the importance of the current study is that it provides unique data about Icelandic speech acquisition within words and within consonant clusters. Consonant clusters and consonants within words hold an important place in linguistic research in Icelandic; thus, knowledge of the role of word position and word structure on children's speech acquisition provides an invaluable resource for practicing SLPs during assessment and intervention. The current study also provides the first Icelandic data regarding PCC and provides clinicians with a method of quantitatively measuring the accuracy of children's speech sound production. To date, due to the lack of normative PCC data for Icelandic, assessment of PCC has held limited clinical value for SLPs working with Icelandic-speaking children. The findings of this study make this information on PCC specific to the Icelandic context available to clinicians for the first time. Finally, the null finding concerning the relationship between sex and singleton consonant and consonant cluster accuracy indicated that clinicians working with Icelandic-speaking children need not focus upon children's sex when they are conducting assessments of children's speech or providing recommendations for intervention.

Conclusions

This cross-sectional study is the largest and most comprehensive study of Icelandic children's speech to date reporting on 437 typically developing children in Iceland aged 2;6–7;11. It is the first study of Icelandic-speaking children to describe the acquisition of all 47 Icelandic consonants, 45 clinically relevant consonant clusters and PCC for typically developing Icelandic-speaking children. In addition, this study demonstrated the importance of the role of word position in Icelandic speech acquisition. Clinical implications of the findings of this study include that singleton consonants are acquired earlier than consonant clusters and word position influences consonant accuracy. This study adds to cross-linguistic knowledge from the growing number of studies of speech acquisition in a variety of languages worldwide (McLeod & Crowe, 2018) and is one of a few cross-sectional studies to document the acquisition of consonant clusters across a wide age range.

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