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Research Article

Simultaneous bilingualism and speech style as predictors of variation in allophone production: Evidence from Finland-Swedish

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ABSTRACT

This study investigates cross-linguistic transfer in the production of long mid front vowels [øː] and [œː] by simultaneous bilingual Finnish and Finland-Swedish speakers in Finland. In Swedish, the phoneme /ø/ can be realised as the allophones [ø] and [œ], while in Finnish, only [ø] is used. Combining approaches from sociophonetic and bilingual transfer research, the study used acoustic analysis to compare the height and fronting of [øː] and [œː] produced by bilingual and monolingual Finland-Swedish speakers in three different speech styles on a continuum of formality. The data from 115 participants are stratified according to language background, speech style, region, and age. The statistical analysis indicates increased overlap of [øː] and [œː] in the vowel spaces of bilingual speakers, particularly in informal speech. The results suggest a potential effect of Finnish transfer on the distinction of the phonetic variants in simultaneous Finland-Swedish bilinguals, as well as demonstrate the importance of considering speech style in bilingual transfer research.

1. Introduction

Transfer between two or more languages of an individual has long fascinated researchers in the field of linguistics, both as a cause of foreign accent in speakers' second language (L2) (for an overview, see Piske et al., 2001), as well as in the first language (L1) of heritage speakers (e.g., Amengual, 2019; Elias et al., 2017; Kang & Nagy, 2016; McCarthy et al., 2013). In recent years, an increasing number of studies have focused specifically on cross-linguistic transfer between the languages of early and simultaneous bilinguals (e.g., Morris, 2013, 2017: Watson, 2007; Simonet, 2011a, 2011b), paying particular attention to speakers from regions with longstanding language contact. This article seeks to expand on the body of work by exploring contact-induced change in simultaneous Finland-Swedish and Finnish bilingual speakers. In Finland, Finnish and Swedish have been spoken side by side for centuries, but the growing dominance of Finnish in society alongside increasingly frequent linguistic exogamy mean that the majority of Finland-Swedes today are either simultaneous bilinguals, or have learned Finnish as an L2. Examining the potential impact of Finnish societal dominance on Finland-Swedish vowel production, the current study investigates Finnish phonetic transfer in the production of long Swedish mid front rounded vowels [øː] and [œː] in simultaneous Finnish and Finland-Swedish bilinguals.

1.1. Bilingual phonetic transfer

Previous research on language acquisition has consistently demonstrated that the earlier a second language is acquired, the less cross-linguistic influence we may expect (e.g., Flege et al., 1999; Baker & Trofimovich, 2005). The effect of age of acquisition on bilinguals' speech production has been widely researched, with studies indicating that late bilinguals are more likely to show transfer from their L1 in their L2, and demonstrate more difficulty in producing and perceiving target sounds in their L2 (Flege, 1995). While the Critical Period Hypothesis (Lenneberg, 1967; Scovel, 1988) argued that new linguistic features can no longer be acquired after neurological maturation in puberty, subsequent research has shown that foreign accent features may be present in speech of individuals who began learning their L2 in childhood, even as early as 3.1 years of age (Flege et al., 1995). In contrast to the Critical Period Hypothesis, the Speech Learning Model (SLM: Flege, 1995; see also the revised SLM-r: Flege & Bohn, 2021) proposes that the mechanisms used to establish the elements of the L1 pho-

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netic system, including the ability to form phonetic categories, also remain intact and available for L2 learning throughout an individual's lifetime. The SLM posits that although some of the categories formed for L2 sounds will never be identical to those of native speakers, this does not demonstrate a diminished capacity for speech learning (Flege & Bohn, 2021). The variation between L1 and L2 learners may instead be due to other factors, such as L2 learners usually receiving less phonetic input than L1 learners (Flege, 1995; Flege & Bohn, 2021). The SLM further hypothesises that L2 learners may differ from monolingual speakers due to interactions between sounds in the L1 and L2 subsystems, which occur due to the L1 and L2 sounds existing in a common phonetic space.[1] This interaction is described as bidirectional, as L1 and L2 sounds that are linked to one another may come to resemble each other in production (Flege, 1995). Conversely, if contrasts between L1 and L2 sounds are maintained, the L1 and L2 sounds may be deflected from each other in the phonetic space, thus also differing from a monolingual speaker's production of the L2 (Flege, 1995).

The SLM, as well as another theoretical construct, the Perceptual Assimilation Model[2] (PAM: Best, 1995), have considered the importance of non-contrastive phonetic similarities and dissimilarities between L1 and L2 (SLM) or nonnative (PAM) phones, including considerations of "phonetic goodness of fit" (see Best & Tyler (2007) for a model comparison). According to both frameworks, the perceptual differentiation of two contrasting L2 categories is difficult if they are perceptually equivalence-classified to the same existing L1 category (Strange, 2007). The SLM hypothesis posits that equivalence classification is likely to prevent the creation of a new category for an L2 sound "when neighboring L1 categories are fully developed and when the L2 sound is perceived to be phonetically similar to a neighboring L1 sound" (Flege, 2007: 367). In such instances, the SLM predicts that a single long-term memory representation will be used to process instances of the L2 phone and its L1 counterpart, eventually yielding a merged category representing both the L1 and L2 phonetic input.

Although the SLM has been highly influential, the original model as well as the SLM-r focus on perception and production in L2 learners, and thus do not address interaction between phonetic categories in the two languages of simultaneous bilinguals. Watson (2007) sought to apply predictions derived from the SLM to simultaneous bilinguals, comparing voicing contrast of French–English bilinguals to French and English monolinguals. The results indicated that while simultaneous bilinguals did produce distinct VOT values in both languages, their production differed from that of the monolingual groups. The findings highlighted the importance of relative exposure to each language, as simultaneous bilinguals living in France diverged more from English monolinguals in England, and bilinguals in England diverged more from French monolinguals. The author argues that the factor of language exposure should be incorporated into an adapted version of the SLM to form a general theory of phonological acquisition (Watson, 2007: 1536).

In fact, numerous studies have shown that very early or even native bilingual experiences do not necessarily result in parallel monolingual-like speech patterns for the speaker's languages (Mayr et al., 2019; Sebastián-Gallés et al., 2005). The two sound systems of a bilingual are in constant interaction, with one affecting the other (Paradis, 2001; Mennen, 2004). Cross-linguistic interaction is also not limited to individual bilingualism, but can, in situations of extended language contact, lead to contact-induced language change (Mennen et al., 2020). A growing number of studies have showed interest in the dynamics between the languages of early or simultaneous bilinguals in such communities. For instance, researchers examining potential cross-linguistic interference in the sound systems of simultaneous or early Welsh-English bilinguals in the United Kingdom have found evidence of convergence of both consonants (Morris, 2013, 2017) and vowels (Mayr, Morris, Mennen, & Williams, 2017). Differences in acoustic realisations of vowel categories of trilingual speakers of Saterland Frisian, Low German, and High German have also been explored, showing similar base-of-articulation for the local varieties of Saterland Frisian and Low German, but not High German (Heeringa et al., 2015; Peters et al, 2017). Phonetic and phonological transfer in early or simultaneous bilinguals has perhaps been most widely explored in bilingual communities on the Iberian Peninsula. Catalan-Spanish bilingual speech production has been extensively researched by (Simonet 2011a, 2011b), who found that Spanish-dominant speakers did not produce the same Catalan mid back vowel contrast as Catalan-dominant speakers did (2011b). Simonet and Amengual (2020) also found that increased language co-activation leads to cross-linguistic vowel convergence in Catalan-Spanish bilinguals. Similarly, language dominance has been shown to be relevant in the production and perception of vowel contrasts in Spanish-Galician bilinguals (see Amengual & Chamorro, 2015; Mayr et al., 2019; de la Fuente Iglesias & Pérez Castillejo, 2020), although results by Tomé Lourido & Evans (2019) indicate that Galician-dominant speakers with Spanish L1 who learned Galician at an early age in a bilingual environment demonstrate similar patterns to Spanish-dominant speakers in the production and perception of mid-vowel and fricative contrasts. In a study examining the production of sibilants in Basque-Spanish bilinguals, Muxika-Loitzate (2017, 2020) found that Spanish-dominant bilinguals demonstrated a merger of the sibilants, while Basque-dominant speakers maintained a significant distinction in the place of articulation.

1.2. The current study

As indicated by the findings of the above studies, long-term language contact situations are likely to result in some cross-linguistic transfer between the languages of bilingual speakers. Consequently, we posit that the speech production of bilinguals in the Finland-Swedish context also warrants investigation. Exploring phonetic transfer in simultaneous Finnish and Finland-Swedish bilinguals, we examine variation in the distinction between the long Swedish mid front rounded vowels [øː] and [œː]. The vowels, which are allophones of /ø/, are

[1] The initial term used was a "common phonological space" (Flege, 1995: 241–242), but we follow the less missleading retroactively applied term "common phonetic space" (Flege & Bohn, 2021: 21).

[2] As the Perceptual Assimilation Model was developed specifically to explain non-native speech perception by naive listeners, the PAM and revised PAM-L2 (Best & Tyler, 2007) are not discussed in detail here.

found in complementary distribution, with the open-mid front rounded vowel [œ] only occurring before /r/. As the close-mid front vowel [ø] is also present in Finnish but [œ] is not, extended language contact between Finnish and Swedish is likely to affect the distinction of the mid front vowels. Reflecting on transfer in simultaneous bilinguals in light of the SLM framework, we explore whether interactions between bilinguals' two languages are found in their phonetic space. To accomplish this, we compare the allophonic production of simultaneous Finland-Swedish and Finnish bilinguals, who typically spoke Swedish with one parent and Finnish with the other, to that of Finland-Swedish individuals who grew up in monolingually Swedish-speaking homes. The differentiating factor is chiefly the linguistic environment of childhood and adolescence, as the vast majority of monolingual Finland-Swedish speakers are also – to some degree – Finnish L2 speakers, and there are thus very few truly monolingual Finland-Swedish speakers in mainland Finland.

The project expands on a previous study by Strandberg (2018), which explored the production of [ø] and [œ] in 14 Finland-Swedish bilingual and monolingual speakers. The findings of Strandberg (2018), discussed in detail in Section 2.3, suggested that simultaneous and early Finland-Swedish and Finnish bilinguals were more likely to have converging F_1 values for [œ] and [ø]. The current project considerably expands on the limited research scope of this earlier project by examining variation in the long vowels [øː] and [œː] in 115 Finland-Swedish speakers. Crucially, we also consider the speech style in which the samples are obtained. Although the vast majority of studies investigating cross-linguistic influence in early onset bilinguals have been conducted in laboratory conditions, in recent years there has been an increase in the use of interviews to examine bilingual transfer (see Nance, 2013; Morris, 2013, 2017; Davidson, 2015; Mooney, 2019; Muxica-Loitzate, 2017, 2020). Due to the impact that speech style has been shown to have on language use in variationist research, the current study used sociolinguistic interviews to obtain vowel samples from participants in three different speech styles: spontaneous speech, when reading a text, and when reading minimal pairs. This approach allows for the examination of intra-speaker variation based on three contextual styles on a continuum of formality (Labov, 2001).

Despite the main focus being phonetic variation due to bilingual transfer, the study also takes into consideration the factor of regional background. Finland-Swedish is often considered a single homogenous dialect, and previous research investigating Finland-Swedish vowel production has generally contrasted Finland-Swedish as a unit with other varieties, mainly Central Standard Swedish[3] and other dialects spoken in Sweden (Leinonen, 2010; Helgason et al., 2013), or, on occasion, Estonian Swedish (Ewald et al., 2017). The current study acknowledges the variability of Finland-Swedish dialects, and aims to explore regional variation in possible bilingual transfer features by including participants from three traditionally Swedish-speaking regions in Finland; Southern Finland, Ostrobothnia, and the capital city of Helsinki. Although the Greater Helsinki Region is geographically located in the south of Finland, participants from the capital were considered separately from other Southern dialect speakers because the 'urban' Helsinki variety is often considered to be closest to Standard Finland-Swedish (Østern, 2004). Generally, comparisons of Finland-Swedish dialects have suggested that the largest differences can be found between the Ostrobothnian and the southern Finland-Swedish varieties (Leinonen, 2012), and, while dialect levelling toward the standard language is thought to be occuring in the south, the use of local dialects is widespread (and possibly even increasing, see Ivars 2015) in Ostrobothnia. The regional divisions are also of interest for bilingualism research, because previous studies have shown that Finnish and Swedish bilingualism and linguistic exogamy is particularly common in Helsinki and Southern Finland, while the north-western region of Ostrobothnia remains more linguistically divided (Finnäs, 2012; Leinonen & Tandefelt, 2007). The current study, therefore, seeks to shed light on how both stylistic and regional factors may influence bilingual transfer, and does so with focus on the rarely examined Finland-Swedish variety.

2. Background

2.1. Sociohistorical context

Swedish has a long-established history in Finland, due to the fact that the region was ruled by Sweden from the 12th to the 19th century. Although only 5.2 percent of the population spoke Swedish as their native language in 2019, compared to 87.3 percent who spoke Finnish (Statistics Finland, 2020), the Finland-Swedish variety holds a position as a national language alongside Finnish.[4] Despite Finnish being the dominant language, Finland-Swedes have traditionally upheld a strong linguistically anchored ethnic identity, given that they tend to be defined by their native language (Skutnabb-Kangas, 1999; af Hällström-Reijonen, 2012); the term 'Finland-Swedish' (Sw. *finlandssvenska*) can be used to refer to both the linguistic variety and its speakers. The relationship between Swedish and Finnish speakers in Finland is thus comparable to that of anglophones and francophones in Canada, where language also acts as the main characteristic for two groups who perceive themselves as distinct (Heller, 1999; Strandberg & Gooskens, in press).

The language rights of Finnish and Swedish speakers are theoretically equal, with individuals of both linguistic groups having the right to education and public services in their native tongue. It is also mandatory to study the second national language in school. Still, the dominance of Finnish in most regions means that fluency in Finnish is more common amongst Swedish speakers than vice versa, and many Swedish speakers are resigned to using Finnish in public spaces (McRae et al., 1997). Whereas historically the two linguistic groups lived in separate regions, industrialisation and urbanisation has led to most historically Swedish-speaking regions (particularly around the Greater Helsinki Region in the south) becoming bilingual or majority Finnish-speaking. Consequently, both flu-

[3] Central Standard Swedish is the variety of Swedish spoken in, amongst other regions, Stockholm. It is generally considered the standard that other varieties are most often compared to.

[4] Languages which are not considered national languages, but which have legally protected status as autochthonous minority languages, include the three Sámi languages found in Finland (Northern Sámi, Skolts Sámi, and Inari Sámi; see, e.g., (Pietikäinen, 2008)), Finnish Romani, the Finnish and Finland-Swedish sign languages, and Kotus.fi (2020).

ent late bilingualism and simultaneous bilingualism amongst Swedish speakers have increased rapidly in the past few generations (Finnäs, 2015; for a comprehensive overview, see Strandberg and Gooskens (in press). However, although the changing sociolinguistic situation and the power dynamic between Finnish and Finland-Swedish have led to continued discussion about the influence of Finnish on the Swedish language, phonetic and phonological variation due to this language contact situation is commonly overlooked.

2.2. Finnish transfer in Finland-Swedish

As a result of the close contact with the Finnish language, the Finland-Swedish variety is rarely discussed without mentioning transfer features from Finnish. Existing literature has largely focused on lexical and syntactic transfer, highlighting borrowed words and constructions from Finnish that are typical of the Finland-Swedish vernacular (see Jamrowska, 1996; Forsskåhl, 2005; Clyne et al., 2009). Yet, while Finnish transfer features in the Finland-Swedish lexicon have received a moderate amount of attention, few studies have focused on exploring phonetic transfer features. In one of the few exceptions, Kim (2006) studied intonation patterns in seven Finland-Swedish dialects from Southern Finland and Ostrobothnia. In the small-scale study, which made use of recordings of one elderly speaker per dialect, pitch accent was examined in words with two or more syllables. The results showed that many Finland-Swedish speakers displayed falling intonation, similar to that found in Finnish. Specifically, falling pitch accents were found in regions with heaviest contact with Finnish, indicating Finnish influence on Finland-Swedish in these regions (Kim, 2006: 79). Influence from Finnish has also been suggested in consonant production: (Kuronen & Leinonen, 2001, 2011) propose that Finland-Swedish /r/, /t/, /v/ and /j/ have most likely been influenced by Finnish due to their similarity to the Finnish rather than Central Standard Swedish consonants. However, research on Finnish transfer features in Finland-Swedish vowel production has mainly been restricted to discussions regarding vowel contrasts. Unlike in Central Standard Swedish, qualitative differences between long and short vowels are very small or non-existent in Finland-Swedish; instead, vowel quantity is more important in Finland-Swedish, a trait that has been attributed to Finnish influence (Helgason et al., 2013; Kuronen & Leinonen, 2001, 2011; Reuter, 1971).

Although the aforementioned features have been attributed to language contact with Finnish, very little attention overall has been paid to potential cross-linguistic influence of Finnish on Finland-Swedish vowel production. In the following section, we present the only studies (that we are aware of) that have addressed the possibility of Finnish influence on Finland-Swedish vowels, and we refer to a few notable studies on cross-linguistic transfer in the vowel production of simultaneous bilinguals in other languages.

2.3. Cross-linguistic transfer in vowel spaces

In one of the few studies to address vowel variation as a result of bilingual transfer in Finland-Swedish, Kuronen (2000) examined Finnish, Finland-Swedish, and Central Standard Swedish vowel production. The study compared F_1 and F_2 frequencies of 16 male participants: four monolingual Finnish speakers, four native and four childhood bilingual Finland-Swedish and Finnish speakers, and four monolingual Swedish speakers from Sweden. Six out of the eight native or early bilingual participants used largely the same vowel system in both Finnish and Finland-Swedish. Notable differences were limited to the production of Finnish [yː], where bilingual participants demonstrated higher F_2 values than monolingual Finnish speakers from the same region, and [eː] and [øː], where they demonstrated comparatively lower F_1 values than their Finnish counterparts. Specifically interesting for the present study is that one of the four native bilingual participants did not show any difference in the production of [øː] and [œː], instead producing both as close-mid vowels (Kuronen, 2000: 181). According to Kuronen (2000), the results suggest that bilingual speakers may struggle to separate the qualitatively similar vowel systems, particularly in cases where using either vowel system is communicatively sufficient for both languages. Furthermore, in accordance with other sources, when comparing Finland-Swedish and Central Standard Swedish samples, Kuronen (2000) notes that Finland-Swedish speakers rely on quantity for distinguishing between long and short vowels, while Central Standard Swedish speakers rely on quality.

As previously mentioned, the current project expands on the study by Strandberg (2018), which examined variation in the F_1 and F_2 frequencies of allophones [œ] and [ø] in the speech of 14 participants. The participants were aged 5 to 84 and consisted of three generations of speakers from an extended family from Southern Finland. Due to the young age of some of the participants, speech samples were collected through a photo-elicitation task, in which participants described images designed to elicit target words containing target allophones. The acoustic analysis indicated some differences in vowel production between older participants (aged 51–84), who had learned Finnish in later childhood, and younger participants (aged 5–37), who were simultaneous or early bilinguals.

Although no significant generational change was apparent for fronting, F_1 values for [œ] and [ø] suggested increased overlap between allophones for the participants who were early or simultaneous bilinguals, indicating that age of acquisition correlated with distinction of the phonetic variants with regard to vowel height. Conversely, the older participants, who had all acquired Finnish after the age of 5, produced significantly different formant values for the phonetic variants. The study also showed considerable overlap between formant value distributions for male and female participants, suggesting little impact of gender on allophonic production.

Strandberg (2018) also examined variation in perception of the mid front rounded vowels between simultaneous bilingual and monolingual Finland-Swedes. In an online survey, participants were asked to match target words containing either the open or close front rounded vowel to other words containing the same vowel sound. Participants could indicate that (i) the vowel in the target word was the same as the vowel sound in one (or several) of the other words; (ii) all the words contained the same vowel sound, or; (iii) the vowel in the target word did not match any of the other words. The study found that while all participants struggled more to match target words with [œ] to other words with the same phonetic variant, bilingual participants performed significantly worse than monolinguals in matching words containing [œ] and [ø] to other words with the same allophone.

Although research examining Finnish and Finland-Swedish phonetic transfer is very limited, the impact of extended language contact on the vowel systems of simultaneous bilingual speakers has been explored in other language contexts. A notable example is Simonet (2011b), who investigated the Catalan-specific contrast of mid back vowels /o/ and /ɔ/ in Spanish-Catalan bilinguals from a bilingual speech community on Majorca. The study compared F_1 and F_2 frequencies in production by Catalan-dominant and Spanish-dominant speakers, with results indicating that while Catalan-dominant speakers produced a contrast between /o/ and /ɔ/ in both vowel height and fronting, this contrast was not realised in the Catalan production of the Spanish-dominant speakers (Simonet, 2011b). Instead, the Spanish-dominant participants produced a vowel that was intermediate (on the F_1 dimension) to the two vowels produced by Catalan-dominant speakers, although it resembled Catalan /o/ more than /ɔ/.

Cortés et al., (2019) examined the sociolinguistic factors associated with variation in the production of the mid front /e/ and /ɛ/ contrast by 36 Spanish-Catalan speakers in Barcelona, Spain. The findings suggested that the language of the environment was a strong predictor for variation in vowel production; the auditory and acoustic analysis indicated that all participants were able to consistently distinguish between the two vowels, except for bilingual children from the neighbourhood with high Spanish presence. Although they spoke Catalan at home, the children living in a Spanish-dominant environment did not differentiate between /e/ and /ɛ/, suggesting that the dominant language of the environment was the strongest predictor distinguishing between the vowels (Cortés et al., 2019).

Within the framework of the SLM (see Section 1.1), Mooney (2019) examined phonological and phonetic transfer from Occitan in L2 French mid-vowels produced by early Occitan-French bilinguals. The variables were hypothesised to constitute equivalent phonemes in the bilinguals' mental representation, and, according to the SLM, were expected to be stored in a common phonological space. As predicted by the SLM, the study did find that the single back mid vowel phonemic category for Occitan /ɔ/ resulted in speakers not producing a significant distinction between /o/ and /ɔ/ in French, either; instead, these sounds occupied a single phonemic category (transcribed as /O/), which was equated with Occitan /ɔ/ (Mooney, 2019). However, the single French [O] category was shown to have moved away from Occitan [ɔ] by raising and centralising, showing that phonemic transfer did not result in phonetic transfer (Mooney, 2019). As the results indicated that equivalence classification may not necessarily lead to equated sounds coming to resemble each other phonetically, the author argues for revisions to the SLM framework.

The above examples, as well as studies examining phonetic transfer in vowel systems in other language contact situations (e.g., Bullock & Gerfen, 2004a, 2004b; Mayr et al., 2017), suggest that phonological and/or phonetic transfer can, to a certain extent, be expected in prolonged language contact situations. Our study thus constitutes a much overdue examination of cross-linguistic tranfer in Finland-Swedish as a result of extended contact between Finnish and Swedish speakers.

2.4. The variable

The current study examines variation in the production of allophones [øː] and [œː] by simultaneous Finland-Swedish and Finnish bilinguals, compared to Finland-Swedes who grew up in monolingually Swedish-speaking homes. Despite Swedish and Finnish stemming from different language families (Germanic and Finno-Ugric, respectively), Finland-Swedish and Finnish are phonetically relatively similar, although Finnish has fewer allophones. Both languages make use of the phoneme /ø/, but in Standard- and Finland-Swedish the phoneme usually has two allophones in complementary distribution: the close-mid front vowel [ø] (as in *öga* [øːga], 'eye'), and the open-mid front vowel [œ] (as in *öra* [œːra], 'ear') (Leinonen, 2010; Strandberg & Gooskens, in press). The latter, more open vowel, typically only occurs before /r/. Based on open survey responses to Strandberg (2018), some Finland-Swedes are aware of this distribution, describing /ø/ before /r/ as a "softer" or "more open ö." The survey responses also indicated that L1 Finnish speakers were stereotypically thought to struggle with the production of [œ], and some participants provided anecdotal evidence of having noticed that Finland-Swedes strongly influenced by Finnish occasionally displayed the same phenomenon (Strandberg, 2018: 46). Indeed, as the open-mid front rounded vowel does not exist in Finnish, it has been shown to often be produced as [ø] in the L2 Swedish of L1 Finnish speakers (Kautonen, 2019). Since the open-mid front rounded vowel tends be challenging to produce for Finnish speakers, in addition to being a relatively infrequent sound without phonemic status in Finland-Swedish, cross-linguistic transfer from the Finnish majority language could be expected to be seen in decreased distinction between [œː] and [øː] in simultaneous bilinguals.

The current study focuses solely on long vowels, for which the complementary distribution of [œː] before /r/ and [øː] in other contexts is expected in most Swedish varieties. Still, the reader should be reminded of the aforementioned differences between Finland-Swedish and Central Standard Swedish with regard to vowel quality. In Central Standard Swedish, long /øː/ is distinguished from the short vowel through quality as well as length; the short vowel is either transcribed as /œ/ (Hedelin, 1997) or /ø̞/ (Garlén, 2003) (see Leinonen, 2010). However, as previously mentioned, the presence of these qualitative differences in Finland-Swedish are debated, as Finland-Swedish has much higher focus on vowel quantity (Reuter, 1971; Kuronen, 2000, 2011). Thus, in Finland-Swedish, the open and close vowels are expected to remain in the same complimentary distribution, regardless of vowel length.

Although obtaining up-to-date reference values for Finland-Swedish allophones is challenging due to the lack of acoustic research, we refer to two sets of reference values from Reuter (1971) and Kuronen (2000). The mean F_1 and F_2 Hz values provided by these studies are summarised in Table 1. Notably, while both studies show [œː] to be more open and less fronted than [øː], the differences are smaller in the study by Kuronen

Table 1
Reference F_1 and F_2 Hz values for allophones [øː] and [œː] in Finland-Swedish from Reuter (1971) and Kuronen (2000), and for [øː] in Finnish from Kuronen (2000). N = 4 for each group in both studies.

	vowel	Reuter (1971)		Kuronen (2000)	
		F_1	F_2	F_1	F_2
Finland-Swedish	œː	524	1146	468	1206
Finland-Swedish	øː	406	1895	433	1795
Finnish	øː			459	1608

(2000), particularly for F_1. Kuronen (2000) also provides mean values for [øː] produced by four Finnish speakers. It should be noted that both Reuter (1971) and Kuronen (2000) obtain their respective samples from four male speakers, thus only providing indicative reference values for the present study.

2.5. Sociolinguistic interviews

Since its inception in the 1960s, the Labovian sociolinguistic interview has been considered one of the main methods for acquiring variationist data for quantitative analysis, because it allows the researcher to gather a considerable quantity of naturalistic speech data in a relatively short time (Moreno-Fernández, 2016; Schilling, 2013a). While obtaining samples of participants' vernacular styles is perhaps the most important goal, traditionally the sociolinguistic interview also includes a variety of contextual styles on a continuum of formality (Labov, 1984; Becker, 2017). The resulting shift between different speech styles is used to give an indication of how the speaker may behave in different types of interactions (Eckert & Labov, 2017). The sociolinguistic interview presumes that the type of speaking task influences the amount of attention the speaker pays to their speech, and thus the speaker's formality continuum can be accessed by regulating this attention (Becker, 2017). Theoretically, the most attention to speech is paid when reading individual words or minimal pairs, whereas a lesser, but still relatively high amount of attention is also paid when reading a passage of text. Labov (2001) posits that the most naturalistic informal speech that can be obtained in an interview setting is spontaneous speech, a style that can be observed when the participant pays little to no attention to the interview setting: for example, when talking to a third party, reciting childhood rhymes or games, or discussing an emotional topic.

Because the goal of the researcher is generally to guide the participant into having a relaxed dialogue, Tagliamonte (2006) posits that the term 'sociolinguistic interview' is a misnomer, as this way of data collection should be anything but an 'interview' (2006, p. 37). The general premise that naturalistic speech can be obtained in an interview situation has also been criticised, with discussions largely focusing on how the power imbalance between the interviewer and the interviewee may impact the interviewee's speech production (e.g., Wolfson, 1976; Labov, 1986; Milroy & Gordon, 2003). It has also been pointed out that individuals do not possess a singular "genuine" unselfconscious vernacular that can be accessed in an interview, but that people's everyday speech also varies from more unselfconscious relaxed speech to stylfised self-conscious linguistic usages (Schilling, 2013b). A number of studies have sought to address these issues with modifications of the sociolinguistic interview, for instance, by interviewing several participants at once (Labov et al., 1968; Coupland, 1980), or by allowing participants to record themselves in the researcher's absence (Sebba, 1993; Stuart-Smith et al., 2007). Yet, even these modifications have been found to be problematic, as larger groups and overlap in speech mean more difficulty in obtaining acoustic samples for individuals. In defense of the sociolinguistic interview, it has also been argued that the power asymmetries in the one-on-one interview are often resolved after a certain time, as the interviewees warm up to the situation and are allowed to take control of the conversation (Schilling, 2013b).

Another point of critique regarding the sociolinguistic interview has been the extent to which style-shifting between the various speech contexts in the interview relate to stylistic variation in everyday speech (Coupland, 1980). However, it should be noted that the use of contextual styles as a controlled device in sociolinguistic interviews is concerned with intra-speaker variation within the interview, and it should not be confused with style-shifting as a naturalistic, ethnographic phenomenon (Labov, 2001, 2006; Becker, 2017). Labov clarifies that the organisation of contextual styles based on attention paid to speech within the sociolinguistic interview is "not intended as a general description of how style-shifting is produced and organised in every-day speech" (2001: 87); instead, the formality continuum is a method of organising and using intra-speaker variation that occurs within the interview. As such, it differs from some finer interactional measures proposed for studies of group dynamics and style variation (e.g., Sharma & Rampton, 2015).

Despite its limitations, the sociolinguistic interview does provide a realistic way of conducting large numbers of reproducible interviews in communities, and, specifically, for examining intra-speaker variation within those interviews (Labov, 2001: 85). As Schilling (2013b: 111) states, "it is really difficult to devise a better instrument than the sociolinguistic interview in terms of efficiently obtaining large quantities of high-quality recorded speech that closely approximates everyday speech." Consequently, the sociolinguistic interview was deemed appropriate for the present study. In order to compare speech data from the participants in different modes of formality, the current study obtained samples in three different speech styles; when reading a word-list of (near)-minimal pairs, when reading a short text, and when producing the aforementioned spontaneous speech. The process of data collection is described in detail in Section 3.2.2.

3. The study

3.1. Research questions

The main focus of the study is the examination of potential variation in vowel formant frequencies in terms of vowel height (F_1) and fronting (F_2) for allophones [øː] and [œː] in simultaneous Finnish and Finland-Swedish bilinguals. Based on previous research on convergence due to cross-linguistic influence in bilinguals, our hypothesis is that simultaneous Finnish and Swedish bilinguals will demonstrate reduced distinction between the allophones [øː] and [œː] when speaking Finland-Swedish, compared to monolingual participants. Applying the SLM framework for L1-L2 interaction to simultaneous bilinguals, this decrease or loss of allophonic distinction would be expected to present itself either (1) with [œː] demonstrating lower F_1 and higher F_2 values, thus being produced more like [øː], or (2) with a merger, in which both vowels move closer to each other in the phonetic space.

Focusing on the continuum of formality in the interview, our second research question is twofold. Firstly, we examine whether potential variation in the degree of convergence between the two allophones is related to speech style. Allophones produced in the most naturalistic setting (i.e., spontaneous speech), are expected to demonstrate the most overlap, while vowels produced in formal situations (when reading a text or minimal pairs), are expected to be more distinct. If the data indicate variation due to the effect of speech style, as the research design posits, greater differences between monolingual and bilingual speakers could also be expected in spontaneous speech – where the participants are thought to pay the least attention to their speech – compared to more formal contexts.

Our third research question examines two possibly contradictory theories regarding geographical variation in allophone distinction. Based on studies such as Cortés et al. (2019), which suggest that the degree of dominant language presence in the community can affect the production of vowels, the degree of Finnish presence in traditionally Swedish-speaking regions could be expected to influence the [øː]–[œː] distinction. Thus we might expect more evidence of overlap between phonetic variants in the southern regions. On the other hand, the most standard-like Finland-Swedish is often considered to be spoken in the south of the country, while, as Ivars (2015) argues, local dialects continue to thrive in Ostrobothnia. Consequently, more standard-like realisations of the allophones could be expected in the speech of participants from Southern Finland and, in particular, Helsinki, compared to Ostrobothnia. Our third research question, therefore, examines the relationship between regional background and allophonic distinction by considering standard language norms and regional language dominance. As with language background, speech style is also expected to interact with regional background, in that samples from informal speech contexts are expected to demonstrate more variation than samples from formal contexts.

As our participants consist of individuals from a variety of ages, we also consider the potential relationship between age and the production of distinct phonetic variants. If we find the distinction between [øː] and [œː] to be less prominent in the speech of simultaneous bilinguals, we use the apparent-time method to examine change over time in the variation of the target allophones, comparing the production of younger and older participants.

3.2. Methodology

3.2.1. Participants

A total of 115 Finland-Swedish individuals were interviewed for the study. Forty-six participants were simultaneous bilingual Swedish-Finnish speakers, having been exposed to both Finland-Swedish and Finnish from birth throughout their childhood and adolescence. These participants also reported continous use of both languages throughout their lives, usually in different contexts (e.g., with parents, with partners, with children, at work). By contrast, the remaining 69 participants came from monolingual Swedish-speaking homes; these participants are defined as ‘monolingual’ based on their native language since childhood. However, as noted earlier, the vast majority of monolingual Finland-Swedish speakers have also acquired L2 Finnish in adolescence or adulthood, as there are very few truly monolingual Finland-Swedish speakers.

The participants were aged 18 to 91, with an average age of 45.6 years. The participants were placed into three groups based on their ages, to reflect approximate generations of 20 years: 18–35 years (N = 34), 36–55 years (N = 43), and above 56 years (N = 38). It should be noted that, although the oldest group had the widest dispersion, very few participants were above 75 years old.

The participants were stratified according to their regional background based on two of the traditional Finland-Swedish dialect regions defined by Tandefelt (2007), i.e., Ostrobothnia (N = 40) and Southern Finland (N = 35). Participants from the Greater Helsinki Region (N = 40) were differentiated from other participants from Southern Finland to examine the allegedly most ‘urban’ and standard-like Finland-Swedish variety (Østern, 2004).[5]

3.2.2. Data collection

Participants were interviewed individually, with the majority of the interview structured around open questions. Although the interview structure was designed according to conversational modules traditionally used in sociolinguistic interviews (see Labov, 1984; Tagliamonte, 2006), this structure was never followed ridigly. Since the main goal of the interview was to elicit spontaneous speech, the planned progression of questions was often overlooked in favour of allowing participants to discuss topics in which they themselves were truly interested.

After the conversational part of the interview, the participants were asked to read a passage of text, i.e., an adaptation of Little Red Riding Hood (Sw. *Rödluvan*).[6] While sociolinguistic and dialectology studies involving American English often make use of stories such as Arthur the Rat or The North Wind and the Sun to obtain representation of all phonemes, we adapted the well-known story of Little Red Riding Hood to allow for sufficient repetitions of the Swedish target allophones. Similarly to Nance (2013), who used a version of The Boy Who Cried Wolf as a reading passage, Little Red Riding Hood was selected as an easy text of a well-known story that would not make participants feel too self-conscious when reading aloud.

In the final task, participants were asked to read a list of near-minimal or minimal pairs out loud. Minimal pairs are pairs of words that differ by a single phoneme in standard speech, but which may or may not differ in other varieties (Gordon, 2012; Schilling, 2013a). As the Swedish vowels [øː] and [œː] appear in complementary distribution, there are strictly speaking no minimal pairs for these two vowels. The study instead

[5] The demographic and linguistic data of the participants can be found in Table 11 in the Appendix.

[6] Written by the Brothers Grimm, the version used in the study was loosely adapted from *Rödluvan och vargen*, available on Godnattsagan.se (n.d)

Table 2
Examples of target words for sampling in the contexts of (near-) minimal pairs and when reading a passage of text. Narrow transcriptions of expected Finland-Swedish productions and English translations are included.

Minimal pairs	
öga [øːga] 'eye'	*öra* [œːra] 'ear'
rök [røːk] 'smoke'	*rör* [rœːr] 'pipe'
dög [døːg] 'was fit for'	*dör* [dœːr] 'dies'
höna [høːna] 'chicken'	*höra* [hœːra] 'hear'
kön [køːn] 'the queue'	*kör* [kœːr] 'choir'
Reading passage	
ögon [øːgon] 'eyes'	*öron* [œːron] 'ears'
röda [røːda] 'red'	*föra* [fœːra] 'bring'
bröd [brøːd] 'bread'	*smör* [smœːr] 'butter'
röt [røːt] 'growled'	*hör* [hœːr] 'hear'
gröna [grøːna] 'green'	*göra* [jœːra] 'to do'

made use of near-minimal pairs, such as *öga* and *öra*, or minimal pairs with one word containing one of the studied vowels, e.g., *bör*, 'must', and *bär* 'carries'. Examples of the target words for minimal pairs and the reading passage are provided in Table 2.[7]

The interviews were recorded using a TASCAM DR-100 MKII recorder with a Sennheiser E845 table-top microphone. The recorder was set to 24-bit/96 kHz, and the audio files were saved in WAV format. As interviews were conducted with a single participant at a time, the recorder and the table-top microphone were able to produce high-quality recordings suitable for acoustic analysis. Ethical approval was obtained before the study, and all participants signed an informed consent form. The participants were aware beforehand that the interview would involve questions about language use and attitudes, but they were only informed about the precise nature of the study after the interview. None of the participants had independently identified the purpose of the study.

3.2.3. Acoustic analysis

The target vowels were segmented from the interview recordings using the acoustic analysis software Praat (Boersma & Weenink, 2018) by examining waveforms and spectrograms. The vowels were annotated manually according to their expected productions in the target words, with vowel onsets and offsets identified through formant trajectories and intensity contours. Using the formant tracker, the first and second formants were measured at the vowel mid-point (Thomas, 2014). To ensure measurements of stable vowels, F_2 tokens with linear drop of more than 300 Hz between 25% and 75% were excluded (based on Kim 2005), as were tokens in which the vowel formant was highly articulatorily reduced, in which coarticulation of adjacent segments occurred, or where the formant structure was not clear (e.g., Thomas, 2014; Smakman, 2006; Strandberg, 2018). The frequency maximum was set at 5000 Hz for male and 5500 Hz for female participants, with a window length of 25 ms and a dynamic range of 30 dB to minimise the effect of background noise.

It should be noted that certain Ostrobothnian dialects have a tendency to diphtongise some long vowels, including /øː/ (see Ivars, 2015). Since the current study focuses on monophthongs, samples in which participants produced clear diphthongs were discarded.

The goal was to obtain eight tokens for minimal pairs, five tokens for reading, and six tokens for spontaneous speech for each speaker (19 x 115 = 2,185), which for both vowels would equal 4,370 tokens. With 329 tokens missing or excluded due to various reasons, the total number of tokens was 4,041. The minimum number of required samples was three tokens per vowel per context per speaker, a goal that was achieved in all cases except for one speaker in the context of reading. The final average number of tokens was 18.25 for [œː] and 16.89 for [øː] for each speaker.[8]

In order to obtain the vowel spaces for the speakers and perform normalisation, formant samples were extracted from the target vowels as well as additional vowels produced by the speakers.[9] As existing reviews of normalisation procedures (e.g., Flynn & Foulkes, 2001; Adank et al., 2004; Fabricius et al., 2009; Clopper, 2009), have pointed to the vowel-extrinsic, formant-intrinsic, and speaker-intrinsic Lobanov (1971) and Nearey (1977) methods as some of the best-performing normalisation procedures for sociolinguistic data, these two procedures were considered the two most appropriate options for the present study. Therefore, a sample of the data was transformed according to both the Lobanov and Nearey methods using the *vowels* package (Kendall & Thomas, 2018) for the computing language R. Visual comparison of the normalised data and the raw Hz values indicated that the Nearey individual log-mean method was a better fit for the data, and thus the formant-intrinsic Nearey transformation was used on the full data set.

3.3. Results

Using the *lme4* package (Bates et al., 2020) for R (R Core Team, 2020), linear mixed models were fitted to predict F_1 and F_2 of allophones [øː] and [œː]. The models included the random effect of speaker with random intercepts,[10] alongside vowel type (close-mid, open-mid) and style (minimal pairs, reading, spontaneous speech) as within-subject fixed factors, as well as language background (bilingual, monolingual), regional background (Southern Finland, Helsinki, Ostrobothnia), and age (18–35, 36–55, 56+) as between-subject fixed factors. Since our study does not focus on variation due to gender-related practices, and the normalisation was expected to remove effects due to physiological differences, gender was not included as a predictor. The statistical models were fitted with predictors and interactions using step-up modelling, and the resulting best-fitting models are discussed. Contrasts were applied to all factors using sum-coding, wherein each level is compared to the factor mean. The main effects and pairwise comparisons for interaction effects are discussed according to predictor in the following sections. For the linear mixed models,[11] we report the

[7] A complete list of words (Table 13) and the reading passage are included in the Appendix.

[8] Table 12 in the Appendix demonstrates the average number of samples per vowel per speaker per style.

[9] Although the paper focuses on the allophone pair [ø] and [œ], a total of eight vowels, including three point vowels, were sampled for each participant: [a, i, u, æ, ø, œ, e, ϵ].

[10] Because the data consist of one average normalised Hz value for each participant in each speech style, it is not possible to estimate random slopes for this model, as the variance in the slopes would be confounded with the residual variance (see Bolker, 2012).

[11] Summaries of the mixed model outputs (Tables 14 and 15) as well as the mean normalised F_1 and F_2 values for the groups (Tables 16 and 17) are included in the Appendix.

standardised beta coeffcients (β), the standard error (*SE*), and the t- and p-values. The alpha level was set to 5%. For interaction effects, pairwise comparisons with Bonferroni correction were conducted using the *emmeans* package (Lenth et al., 2020), and for these we report the t-ratio, degrees of freedom, and p-value. The vowel plots displayed in this manuscript were created in Matlab (2018) using the *gramm* toolbox (Morel, 2018).

3.3.1. Vowel type

Both linear mixed models indicated a main effect for vowel type. The main effect for vowel in the model predicting normalised F_1 values indicated that the close-mid vowel [øː] has significantly lower values than the mean (β = −.24, t = −8.07, p < .001). Conversely, the model for normalised F_2 values demonstrated significantly higher values for the close-mid allophone than the mean (β =.81, t = 55.29, p < .001). These are expected results based on the reference values from Reuter (1971) and Kuronen (2000), as the close-mid vowel [øː] would be expected to be produced with lower F_1 formant frequencies and higher F_2 frequencies than [œː].

3.3.2. Style

Both models indicated significant main effects of speech style for minimal pairs and reading compared to the mean (averaged over both vowels). However, interaction effects of style and vowel type were also found in each model; Fig. 1 visualises the production of the two allophones according to the three speech styles.

For vowel height, pairwise comparisons of the interactions between vowel type and style are demonstrated in Table 3. The contrasts show that, for [œː], the F_1 values in minimal pairs are higher than those in spontaneous speech (t(543) = 3.11, p =.006), while the opposite is true for [øː] (t(543) = −9.56, p < .001). F_1 values are significantly higher in reading than in spontaneous speech for [œː] (t(544) = 12.18 p < .001), but for [øː] the difference is non-significant (t(544) = 1.29 p =.598).

For vowel fronting, pairwise comparisons for the interaction of vowel and style are demonstrated in Table 4. The pattern for second formant values was the opposite of that of F_1, with values for [œː] in minimal pairs being signifcantly lower than those in spontaneous speech (t(551) = −10.54, p < .001), and the opposite being found for [øː] (t(551) = 12.31, p < .001). However, in the case of fronting, no significant difference was found between the contexts of reading and spontaneous speech for the close-mid vowel [øː], and for [œː] the contrast between minimal pairs and reading was also non-significant at t(552) = 0.67, p < 1.000.

The statistical analysis indicates that for both allophones [øː] and [œː], there is a significant effect of style, with speakers producing different F_1 and F_2 values in minimal pairs, reading, and spontaneous speech. The statistical analysis combined with Fig. 1 suggest that the distribution for the two allophones are shown to be most distinct in samples obtained when participants are reading minimal pairs, with increasing overlap between the vowels in reading, and in spontaneous speech. The mean values for the allophones in the context of minimal pairs are similar to the reference values in Section 2.4: 391 Hz (F_1) and 1703 Hz (F_2) for [øː], and 421 Hz (F_1) and 1335 Hz (F_2) for [œː].

3.3.3. Language background

In the model predicting vowel height, no main effect was found for language background; however, two-way interactions of vowel and language background (β =.15, t = 5.07, p < .001) and style and language background (β =.08, t = 2.03, p =.043), as well as a three-way interaction of vowel, language, and style were shown to be significant (β = −.09, t = −2.18, p =.030). Similarly, in the model predicting vowel fronting, a three-way interaction between vowel type, speech style, and language background (β =.04, t = 2.15, p =.032) was found. The distributions of normalised F_1 and F_2 values for allophones [øː] and [œː] in different speech styles according to the language background of the speaker are visualised in Fig. 2.

Pairwise comparisons for the three-way interaction between vowel, language, and style when predicting F_1 are shown in Table 5. The comparisons show significantly lower normalised values in [œː] for bilingual speakers in the context of minimal pairs (t(611) = −2.82, p =.005) as well as in spontaneous speech (t(611) = −3.79, p < .001), but not in reading (t(611) = 0.12, p =.905). For [øː], pairwise comparisons indicate significantly higher F_1 values for speakers from a bilingual background in spontaneous speech (t(611) = 2.82, p =.005); however, no significant differences were found in the two more formal contexts.

It is notable that if we use pairwise comparisons to examine whether or not speakers differentiate between [øː] and [œː] in different speech styles, we find that the vowels are significantly different for both bilingual and monolingual speakers in all contexts, except for monolingual speakers in spontaneous speech (t(543) = −1.42, p =.156).[12] However, while bilingual speakers produce significantly different values for [øː]–[œː] in spontaneous speech, the direction of the relationship has changed (t(543) = 5.26, p < .001), as bilingual speakers are actually producing higher F_1 values for [øː] than for [œː] in spontaneous speech.

For vowel fronting, the pairwise comparisons for the three-way interaction are visible in Table 6. The results show significantly higher F_2 values for the open-mid vowel [œː] for bilingual speakers compared to monolingual speakers in minimal pairs (t(651) = 3.84, p <.001), reading (t(652) = 6.90, p < .001), as well as spontaneous speech (t(651) = 6.32, p < .001). For the close-mid vowel [øː], pairwise comparisons indicated significantly lower F_2 values for speakers from a bilingual background in spontaneous speech (t(651) = −2.78, p =.006).

Overall, the statistical analysis suggests considerable differences in vowel production between bilingual and monolingual participants. The pairwise comparisons indicate that, in comparison to monolinguals, bilinguals produced significantly lower normalised F_1 values for both minimal pairs and spontaneous speech, and significantly higher F_2 values for the same vowel in all speech styles. These results are mirrored in Fig. 2. As the findings of this study suggest that the allophonic variants are less distinct in the production of simultaneous Finnish and Swedish bilinguals, compared to their monolingual peers, we can reject the null hypothesis for our first research question. The results also have implications for our second research question; while speakers from both groups demonstrate increased overlap between vowels in the context of

[12] See additional Table 18 in the Appendix.

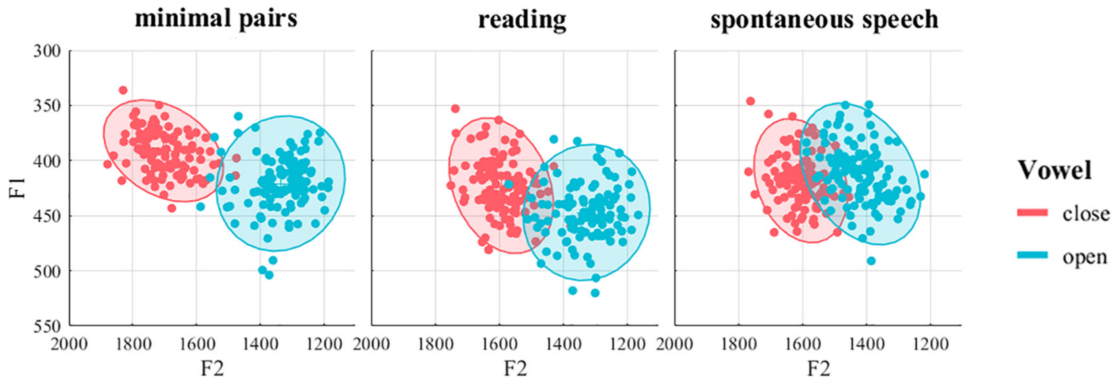

Fig. 1. Vowel plots demonstrating production of the close-mid and open-mid allophones [øː] and [œː] for all speakers in three speech styles, i.e., minimal pairs, reading, and spontaneous speech. The y-axes demonstrate the F_1 interval from 300 to 550 Hz, and the x-axes demonstrate the F_2 interval from 1100 to 2000 Hz. Individual tokens as well as 95% confidence ellipses are shown.

Table 3
Summary of pairwise comparison of normalised F_1 values with the contrast of vowel type (close-mid, open-mid) and the predictor of speech style (minimal pairs, reading, spontaneous speech). For each vowel *N* = 115 for minimal pairs, *N* = 114 for reading, and *N* = 115 for spontaneous speech (total *N* = 688).

vowel	contrast	estimate	SE	df	t-ratio	Sig.
close	minimal pairs – reading	−1.10	0.10	544	−10.82	<.001
	minimal pairs – spontaneous speech	−0.97	0.10	543	−9.56	<.001
	reading – spontaneous speech	0.13	0.10	544	1.29	.598
open	minimal pairs – reading	−0.92	0.10	544	−9.08	<.001
	minimal pairs – spontaneous speech	0.32	0.10	543	3.11	.006
	reading – spontaneous speech	1.24	0.10	544	12.18	<.001

Table 4
Summary of pairwise comparison of normalised F_2 values with the contrast of vowel type (close-mid, open-mid) and the predictor of speech style (minimal pairs, reading, spontaneous speech). For each vowel *N* = 115 for minimal pairs, *N* = 114 for reading, and *N* = 115 for spontaneous speech (total *N* = 688).

vowel	contrast	estimate	SE	df	t-ratio	Sig.
close	minimal pairs – reading	0.67	0.05	552	13.23	<.001
	minimal pairs – spontaneous speech	0.62	0.05	551	12.31	<.001
	reading – spontaneous speech	−0.05	0.05	552	−0.95	1.000
open	minimal pairs – reading	0.03	0.05	552	0.67	1.000
	minimal pairs – spontaneous speech	−0.53	0.05	551	−10.54	<.001
	reading – spontaneous speech	−0.57	0.05	552	−11.19	<.001

spontaneous speech, bilingual participants demonstrated less distinct allophonic production in all three speech styles.

3.3.4. Regional background

In the model predicting vowel height, a main effect of region indicated that speakers from Ostrobothnia produced significantly higher F_1 values for both vowels than the overall mean (β =.15, t = 2.83, p =.006). In addition, the model indicated a near-significant interaction of speech style and region (β =.11, t = 1.94, p =.054), which was explored using pairwise comparisons. Demonstrated in Table 7, the comparisons indicate that speakers from Ostrobothnia produce both vowels with significantly higher normalised F_1 values than speakers from Helsinki ($t(390) = -2.59$, p =.030) and Southern Finland ($t(390) = 2.73$, p =.012) in minimal pairs. This pattern is also found between Ostrobothnia and Southern Finland in the style of reading a text ($t(390) = 3.45$, p =.002); however, no significant regional differences were found in spontaneous speech.

The model fitting F_2 normalised values showed two-way interactions between vowel type and regional background, as well as a three-way interaction of vowel type, region, and style. The distribution of data according to region, vowel type, and speech style is visualised in Fig. 3, and pairwise contrasts for the interaction of vowel type, region, and style in predicting F_2 are demonstrated in Table 8. The results show significantly higher F_2 values for [œː] for speakers from Ostrobothnia compared to Southern Finland in minimal pairs ($t(651) = 5.31$, $p < .001$) and reading ($t(652) = 2.99$, p =.009), with comparatively significant differences in the Helsinki–Ostrobothnia contrast at $t(652) = -6.26$, $p < .001$ for minimal pairs and $t(652) = -4.46$, $p < .001$ for reading.

A similar, although reversed, pattern is visible for [øː], as the normalised values for the close-mid vowel are shown to be significantly lower for Ostrobothnia compared to Southern Finland in minimal pairs ($t(651) = -4.29$, $p < .001$) and reading ($t(652) = -4.15$, p <.001). Likewise, participants from Helsinki demonstrate significantly higher mean F_2 values in minimal

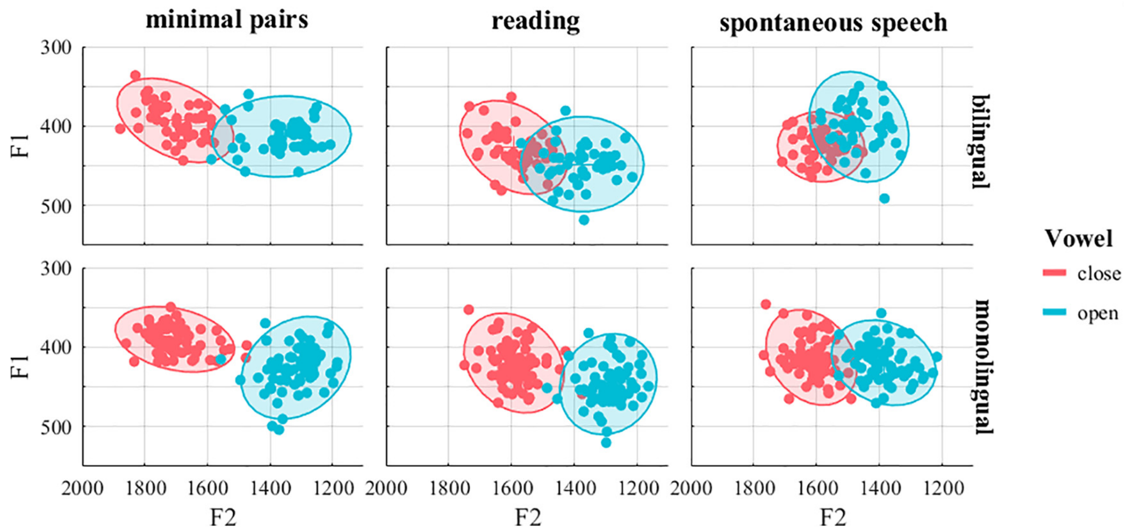

Fig. 2. Vowel plots demonstrating production of the long close-mid and open-mid allophones [øː] and [œː] by bilingual and monolingual speakers in three speech styles, i.e., minimal pairs, reading, and spontaneous speech. The y-axes demonstrate the F_1 interval from 300 to 550 Hz, and the x-axes demonstrate the F_2 interval from 1100 to 2000 Hz. Individual tokens as well as 95% confidence ellipses are shown.

Table 5
Summary of pairwise comparison of normalised F_1 values with the contrast of language background (bilingual, monolingual) and the predictors of vowel type (close-mid, open-mid) and speech style (minimal pairs, reading, spontaneous speech). For each vowel the sample constitutes *N* = 46 bilingual and *N* = 69 monolingual for minimal pairs and spontaneous speech, and *N* = 46 bilingual and *N* = 68 monolingual for reading (total *N* = 688).

style	vowel	contrast	estimate	SE	df	t-ratio	Sig.
minimal	close	bilingual – monolingual	0.11	0.15	611	0.73	.467
pairs	open	bilingual – monolingual	−0.43	0.15	611	−2.82	.005
reading	close	bilingual – monolingual	0.25	0.15	611	1.65	.100
	open	bilingual – monolingual	0.02	0.15	611	0.12	.905
spontaneous	close	bilingual – monolingual	0.43	0.15	611	2.82	.005
speech	open	bilingual – monolingual	−0.58	0.15	611	−3.79	<.001

Table 6
Summary of pairwise comparison of normalised F_2 values with the contrast of language background (bilingual, monolingual) and the predictors of vowel type (close-mid, open-mid) and speech style (minimal pairs, reading, spontaneous speech). For each vowel the sample constitutes *N* = 46 bilingual and *N* = 69 monolingual for minimal pairs and spontaneous speech, and *N* = 46 bilingual and *N* = 68 monolingual for reading (total *N* = 688).

style	vowel	contrast	estimate	SE	df	t-ratio	Sig.
minimal	close	bilingual – monolingual	−0.05	0.07	651	−0.61	.540
pairs	open	bilingual – monolingual	0.28	0.07	651	3.84	<.001
reading	close	bilingual – monolingual	−0.01	0.07	652	−0.15	.884
	open	bilingual – monolingual	0.51	0.07	652	6.90	<.001
spontaneous	close	bilingual – monolingual	−0.21	0.07	651	−2.78	.006
speech	open	bilingual – monolingual	0.47	0.07	651	6.32	<.001

Table 7
Summary of pairwise comparison of normalised F_1 values with the contrast of regional background and the predictor of speech style (minimal pairs, reading, spontaneous speech). The results are combined over factors of vowel type, constituting *N* = 80 Helsinki, *N* = 70 Southern Finland, *N* = 80 Ostrobothnia for minimal pairs and spontaneous speech, and *N* = 80 Helsinki, *N* = 68 Southern Finland, and *N* = 80 Ostrobothnia for reading (total *N* = 688).

style	contrast	estimate	SE	df	t-ratio	Sig.
minimal	Helsinki – Ostrobothnia	−0.35	0.13	390	−2.59	.030
pairs	Helsinki – S. Finland	0.03	0.14	390	0.23	1.000
	Ostrobothnia – S. Finland	0.38	0.14	390	2.73	.012
reading	Helsinki – Ostrobothnia	−0.30	0.13	390	−2.26	.073
	Helsinki – S. Finland	0.18	0.14	390	1.27	.615
	Ostrobothnia – S. Finland	0.48	0.14	393	3.45	.002
spontaneous	Helsinki – Ostrobothnia	0.05	0.13	390	0.40	1.000
speech	Helsinki – S. Finland	−0.04	0.14	390	−0.27	1.000
	Ostrobothnia – S. Finland	−0.09	0.14	390	−0.66	1.000

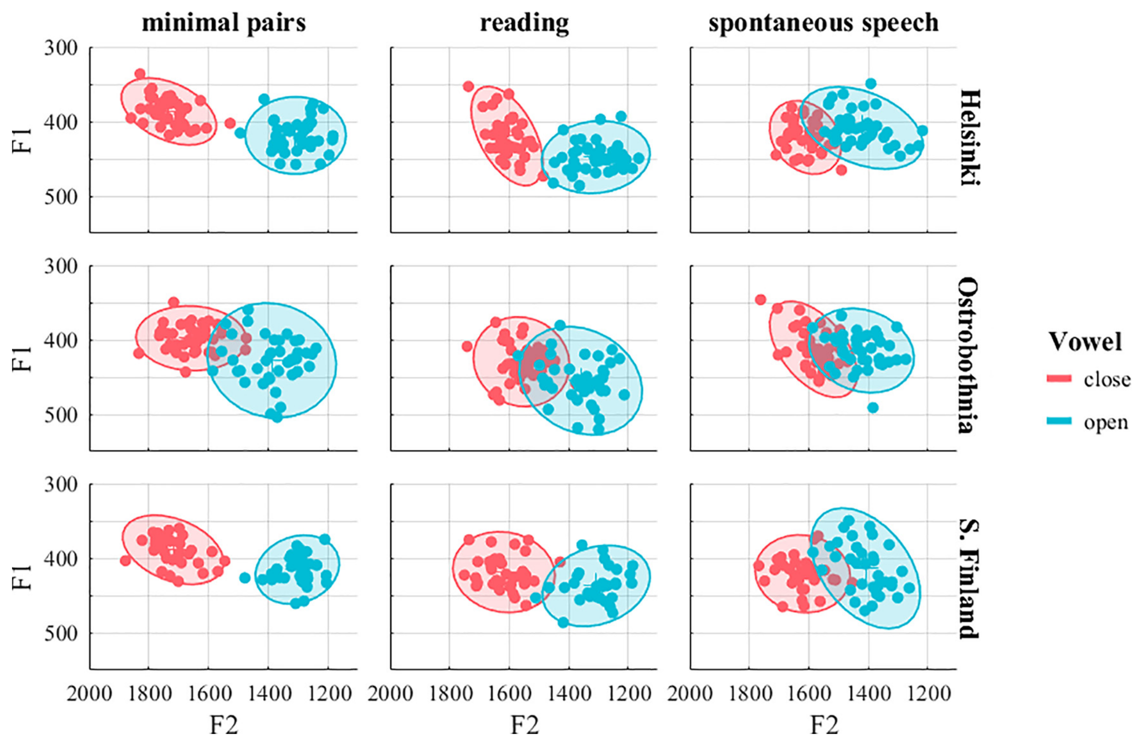

Fig. 3. Vowel plots demonstrating production of the long close-mid and open-mid allophones [øː] and [œː] by speakers from Helsinki, Southern Finland, and Ostrobothnia. The y-axes demonstrate the F_1 interval from 300 to 550 Hz, and the x-axes demonstrate the F_2 interval from 1100 to 2000 Hz. Individual tokens as well as 95% confidence ellipses are shown.

pairs ($t(652) = 5.48$, $p < .001$) and reading ($t(652) = 3.57$, $p = .001$), compared to Ostrobothnians. Interestingly, the only regional contrasts that remain significant in the context of spontaneous speech are those indicating that values for [øː] from Ostrobothnia are significantly lower than in Southern Finland ($t(652) = -2.57$, $p = .031$). No significant or near-significant differences were found between speakers from Southern Finland and Helsinki in any speech style for either vowel, indicating little regional variation in the south of the country.

The findings regarding region are somewhat unexpected, as previous litterature led us to expect the potential influence of Finnish on Swedish vowel production to be more evident in regions with stronger dominance of Finnish, i.e., Southern Finland and Helsinki. However, the pairwise comparisons of interactions involving region suggest that speakers from Ostrobothnia demonstrate more overlap of the two allophones in the contexts of reading a text and reading minimal pairs, although this regional variation is diminished in spontaneous speech.

3.3.5. Age group

In the model predicting normalised F_1 values, a significant three-way interaction of speech style, vowel, and age ($\beta = -.12$, $t = -2.11$, $p = .035$) was found. The distribution of data according to vowel, speech style, and age is demonstrated in Fig. 4. The figure suggests a similar pattern of style variation for all age groups, although the individual plots seem to indicate slightly increasing overlap between vowels in minimal pairs and reading for the younger groups. However, pairwise comparisons for the three-way interaction, demonstrated in Table 9, show that the only differences between age groups were found for spontaneous speech, where speakers in the two younger groups (i.e., 18–35 and 36–55) had significantly lower F_1 values for [œː] ($t(611) = -3.01$, $p = .008$, and $t(611) = -2.63$, $p = .026$, respectively) than speakers from the oldest group. A second pairwise comparison[13] on the production of allophonic variant distinction in different speech styles showed that while the speakers aged 56+ do not significantly differentiate between the allophones in spontaneous speech ($t(543) = -0.56$, $p = .579$), younger speakers do; for both younger age groups the results of the comparison were significant, at $t(543) = 3.46$, $p < .001$ for speakers aged 18–35, and $t(543) = 2.68$, $p = .008$ for speakers aged 36–55. However, as with the bilingual speakers, both younger age groups demonstrate a change of direction of the effect, with higher values for F_1 in [øː] than [œː] in spontaneous speech.

In the model predicting vowel fronting, a main effect of age as well as two-way interaction effects of age and vowel type were found. Pairwise comparisons for the interaction of age and vowel type are demonstrated in Table 10, showing that speakers aged 36–55 produce the close vowel [øː] with significantly higher F_2 values than the oldest group ($t(307) = 2.56$, $p = .033$). On the other hand, for the open vowel [œː], the results show that the youngest group (aged 18–35) produced significantly higher F_2 values than the middle group ($t(306) = 6.14$, $p < .001$) as well as the oldest group ($t(306) = 7.10$, $p < .001$). While this suggests that speakers from the youngest group produce a more fronted version of [œː] than the older groups, it is difficult to assess whether or not this reflects ongoing change, as there is no significant difference between the two older groups with regard to the fronting of [œː].

[13] See Table 19 in the Appendix.

Table 8
Summary of pairwise comparison of normalised F_2 values with the contrast of regional background (Helsinki, Ostrobothnia, Southern Finland) and the predictors of vowel type (close-mid, open-mid) and speech style (minimal pairs, reading, spontaneous speech). For each vowel the sample constitutes $N = 40$ Ostrobothnia, $N = 40$ Helsinki, and $N = 35$ Southern Finland for minimal pairs and spontaneous speech, and $N = 40$ Ostrobothnia, $N = 40$ Helsinki, and $N = 34$ Southern Finland for reading (total $N = 688$).

style	vowel	contrast	estimate	SE	df	t-ratio	Sig.
minimal pairs	close	Helsinki – Ostrobothnia	0.47	0.09	652	5.48	<.001
		Helsinki – S. Finland	0.09	0.09	651	1.01	.944
		Ostrobothnia – S. Finland	−0.38	0.09	651	−4.29	<.001
	open	Helsinki – Ostrobothnia	−0.54	0.09	652	−6.26	<.001
		Helsinki – S. Finland	−0.07	0.09	651	−0.74	1.000
		Ostrobothnia -S. Finland	0.48	0.09	651	5.31	<.001
reading	close	Helsinki – Ostrobothnia	0.31	0.09	652	3.57	.001
		Helsinki – S. Finland	−0.07	0.09	651	−0.72	1.000
		Ostrobothnia – S. Finland	−0.37	0.09	652	−4.15	<.001
	open	Helsinki – Ostrobothnia	−0.39	0.09	652	−4.46	<.001
		Helsinki – S. Finland	−0.12	0.09	651	−1.29	.597
		Ostrobothnia – S. Finland	0.27	0.09	652	2.99	.009
spontaneous speech	close	Helsinki – Ostrobothnia	0.20	0.09	652	2.26	.072
		Helsinki – S. Finland	−0.03	0.09	651	−0.38	1.000
		Ostrobothnia – S. Finland	−0.23	0.09	651	−2.57	.031
	open	Helsinki – Ostrobothnia	−0.08	0.09	652	−0.87	1.000
		Helsinki – S. Finland	−0.05	0.09	651	−0.55	1.000
		Ostrobothnia – S. Finland	0.03	0.09	651	0.28	1.000

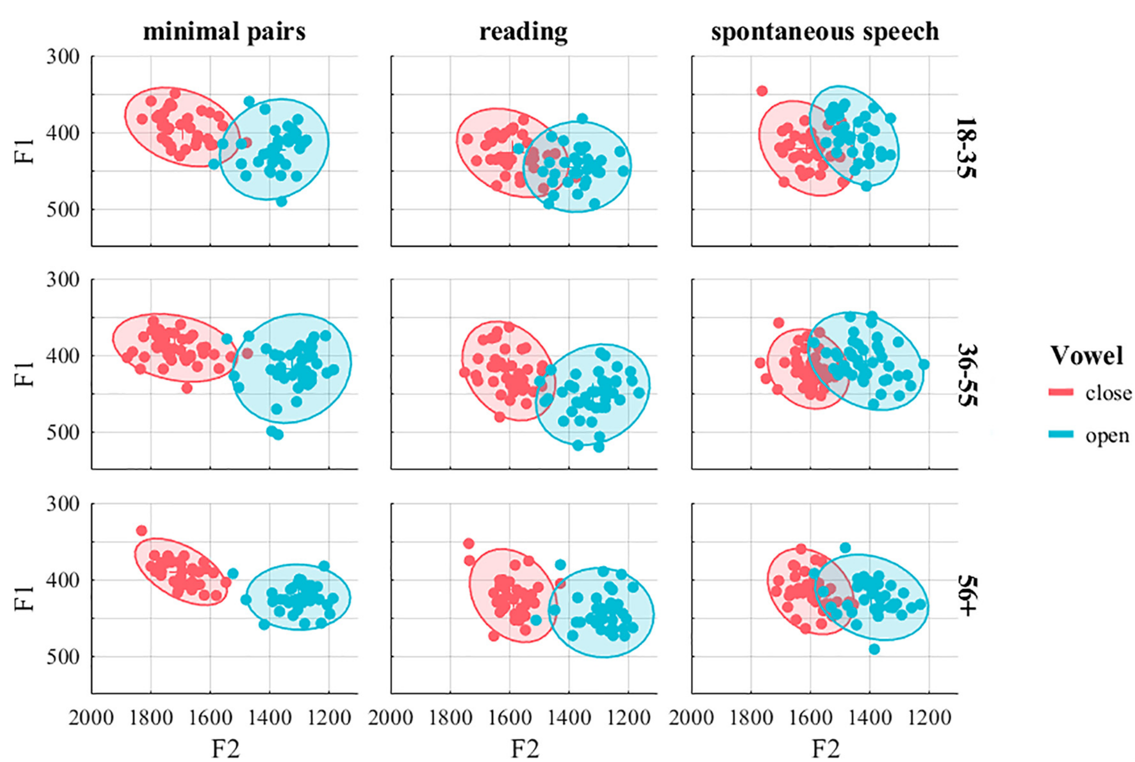

Fig. 4. Vowel plots demonstrating production of the long close-mid and open-mid allophones [øː] and [œː] for speakers in three age groups in three speech styles, i.e., minimal pairs, reading, and spontaneous speech. The y-axes demonstrate the F_1 interval from 300 to 550 Hz, and the x-axes demonstrate the F_2 interval from 1100 to 2000 Hz. Individual tokens as well as 95% confidence ellipses are shown.

4. Discussion

The study sought to investigate whether or not simultaneous Finnish and Finland-Swedish bilinguals differ from monolingual Finland-Swedes in producing distinct variants of allophones [øː] and [œː]. Potential variation was also expected based on the regional background of the speakers, as the dominance of Finnish in society is considered much more prevalent in Helsinki and Southern Finland compared to Ostrobothnia. Furthermore, the inclusion of the predictor of speech style allowed us to examine whether potential effects of linguistic or regional background varied based on the contexts of spontaneous speech, reading a text, or reading minimal pairs.

Whereas the majority of prior research examining cross-linguistic transfer has focused on successive bilinguals, the results of the current study suggest a potential interaction between the phonetic subsystems of the simultaneous bilin-

Table 9
Summary of pairwise comparison of normalised F_1 values with the contrast of age group (18–35, 36–55, 56+) and the predictors of vowel type (close-mid, open-mid) and speech style (minimal pairs, reading, spontaneous speech). For each vowel the sample constitutes *N* = 34 for group 18–35, *N* = 43 for group 36–55, and *N* = 38 for group 56 + for minimal pairs and spontaneous speech, and *N* = 34 for group 18–35, *N* = 43 for group 36–55, and *N* = 37 for group 56 + for reading (total *N* = 688).

style	vowel	contrast	estimate	SE	df	t-ratio	Sig.
minimal pairs	close	18–35 – 36–55	0.13	0.18	611	0.70	1.000
		18–35 – 56+	0.10	0.19	611	0.50	1.000
		36–55 – 56+	−0.04	0.18	611	−0.19	1.000
	open	18–35 – 36–55	0.17	0.18	611	0.91	1.000
		18–35 56+	−0.02	0.19	611	−0.08	1.000
		36–55 56+	−0.18	0.18	611	−1.02	.932
reading	close	18–35 36–55	0.24	0.18	611	1.33	.556
		18–35 56+	0.17	0.19	612	0.87	1.000
		36–55 56+	−0.08	0.18	612	−0.43	1.000
	open	18–35 36–55	−0.25	0.18	611	−1.36	.521
		18–35 56+	−0.01	0.19	612	−0.07	1.000
		36–55 56+	0.24	0.18	612	1.32	.566
spontaneous speech	close	18–35 36–55	0.10	0.18	611	0.55	1.000
		18–35 56+	0.16	0.19	611	0.84	1.000
		36–55 56+	0.06	0.18	611	0.34	1.000
	open	18–35 36–55	−0.10	0.18	611	−0.56	1.000
		18–35 56+	−0.57	0.19	611	−3.01	.008
		36–55 56+	−0.47	0.18	611	−2.63	.026

Table 10
Summary for pairwise comparison of levels in the interaction effect of age group and vowel in F_2. The results are combined over the factor of speech style, and for each vowel the sample constitutes *N* = 102 for group 18–35, *N* = 129 for group 36–55, and *N* = 113 for group 56+ (total *N* = 688).

vowel	contrast	estimate	SE	df	t-ratio	Sig.
close	18–35 36–55	−0.08	0.05	306	−1.51	.396
	18–35 56+	0.05	0.06	306	0.95	1.000
	36–55 56+	0.13	0.05	307	2.56	.033
open	18–35 36–55	0.33	0.05	306	6.14	<.001
	18–35 56+	0.40	0.06	306	7.10	<.001
	36–55 56+	0.07	0.05	307	1.27	.616

gual Finnish and Finland-Swedish participants. The statistical analysis indicates that, specifically in spontaneous speech, bilingual participants produce significantly lower F_1 values and higher F_2 values for [œː], and significantly higher F_1 values and lower F_2 for [øː], compared to the monolingual participants. In the case of fronting, this generally suggests more overlap between the two allophones in Finland-Swedish for simultaneous bilinguals than for participants who were raised as monolinguals. Interestingly, when examining vowel height, pairwise comparisons showed no significant distinction in vowel height between [øː] and [œː] for the monolingual group in spontaneous speech, indicating considerable overlap in the informal style. This is in line with the results of Kuronen (2000): 136, who found that monolinguals did not produce [œː] in a considerably more open way than [øː], and that the allophones differed most with regard to fronting. However, the bilingual samples in the same speech context showed inversion of the normalised F_1 values for the two allophones, with values for [œː] being significantly lower (401 Hz) than those for [øː] (426 Hz). Bilingual speakers thus sometimes seem to produce a [œː] that is more closed than the [øː] allophone, potentially indicating a difficulty with differentiating the phonetic variants. The increased merging of [øː] and [œː] amongst bilingual participants supports the findings of Strandberg (2018), which found that early and native bilingual Finland-Swedish participants were generally more likely to have converging F_1 values for [œ] and [ø] than monolingual speakers. Additionally, while the results of Strandberg (2018) only indicated a correlation between age of acquisition of Finnish and variation of tongue height in distinguishing the open and close front rounded vowels, the current data suggests an effect on fronting as well. These findings relate to both our first and second research questions, suggesting that bilingual speakers generally demonstrate more overlap between the allophones, and that the differences between monolingual and bilingual speakers tend to increase in spontaneous speech.

If we apply the SLM framework on L1-L2 phonetic interactions to our results for simultaneous bilinguals, the findings suggest partial category assimilation of Finnish and Finland-Swedish /ø/. In this case, if a single long-term memory representation exists for /ø/, this may impact the formation of distinct categories for the two Finland-Swedish allophones. Interestingly, the findings of the present study do not indicate a straightforward merger of the two allophones in the phonetic space of bilinguals, as has been the case in previous research on bilingual vowel production (e.g., Simonet, 2011b; Mooney, 2019). Instead, the results seem to suggest that while Finland-Swedish and Finnish bilinguals do have two separate categories for the allophones, they are not as distinct as those of monolingual speakers. However, it should be noted that because the study examines patterns across groups, the results may obscure individual differences between speakers; as previously mentioned, Kuronen (2000) found that one of his bilingual participants did not produce [øː] and [œː] in a significantly distinct way, while the three other bilinguals did.

The fact that learning the subsystem of Swedish would be even partially blocked by existing equivalence classification of Finnish (as it could in L2 learning), does perhaps seem unintuitive, given that simultaneous bilinguals learn both their languages at the same time. Yet, Watson (2007) demonstrated that the extent of cross-linguistic interference in production and preception in simultaneous bilinguals depended on their relative exposure to both their languages, and that this interference could diminish or increase over time. Considering that Finnish is the majority language in Finland, it is likely that the interference from Finnish to Finland-Swedish would be stronger than interference in the other direction. Furthermore, interference from Finnish could increase over time, as Finnish societal dominance tends to be more evident in higher education and working life, compared to the more balanced bilingual exposure of a bilingual childhood home.

Another potential explanation for cross-linguistic interference in the case of the mid front rounded allophones in Finland-Swedish relates to the nature of the sounds in question. In a study on American English-speaking children's allophonic production, Song et al. (2015) examined the use of "canonical" forms of a phoneme versus its phonetic variants in the speech of 2-year-olds. The study showed that children produced the non-canonical phonetic variants less of often than adults, despite receiving input containing both canonical and non-canonical forms. The authors argue that this may partially be a result of children having a different phonological representation from adults; where adults' knowledge of the sound pattern of a language encompasses both phonemes and the phonetic variants, for children the representation may only be at the level of the phoneme (Song et al., 2015: 162). If we consider this theory in relation to Finland-Swedish, it could be argued that children acquire the phoneme /ø/ before its phonetic variants [ø] and [œ]. As a result, if the use of the less commonly occuring allophone [œ] is mastered later, it could be expected that the phone would be susceptible to category assimilation with the pre-existing Finnish and Swedish [ø] in the minds of simultaneous bilinguals.

Our third research question hypothesised that the language of the immediate community would predict the degree of allophonic variation in bilingual and monolingual speakers. If this were the case, individuals from Swedish-majority Ostrobothnia regions would demonstrate less cross-linguistic interference than speakers from heavily Finnish-dominant regions in the south. However, the model comparisons did not show significant interactions of region and language background. Therefore, if the Finnish interference on the production of allophones [øː] and [œː] in simultaneous bilinguals is due to linguistic exposure (as suggested by Watson, 2007), the amount of exposure cannot be assessed exlusively based on the immediate community, but also on accessibility of exposure in society. Even in the remaining regions in Finland that are majority Swedish-speaking, Finnish is likely to be easily accessible for bilinguals due to its dominance in the country as a whole.

Considering speech style, samples from all regions showed significant distinction between F_2 values for allophones [øː] and [œː] in all speech contexts. Interestingly, speakers from Ostrobothnia demonstrated more overlap in fronting between the phonetic variants than speakers from the other two regions in minimal pairs and reading, and, with regard to vowel height, speakers from Ostrobothnia were also shown to produce both allophones with higher F_1 values than speakers from the other regions. However, these regional differences largely disappeared in the informal style. The regional distribution thus suggests that speakers from Southern Finland and Helsinki generally adjust their realisation of the two vowels more according to style than speakers from Ostrobothnia. These results indicate that Ostrobothnian speakers do not seem to aim for the same standard-like vowel production in the more formal contexts of minimal pairs and reading as speakers from the two other regions do. The distinct pattern of Ostrobothnian speakers could be a result of a strong local identity, expressed through retaining regional language features in speech even in more formal speech styles. As Ivars (2015) states, the use of local Ostrobothnian dialects has become more popular in the 21st century, with popular music and radio broadcasts in Ostrobothnian dialects becoming more common. A result of this could be that Ostrobothnians are less sensitive to variation in speech style, thus demonstrating less stylistic variation than speakers from Southern Finland or Helsinki. An alternative explanation is that speakers from Ostrobothnia simply are less exposed to standard Finland-Swedish, thus not necessarily achieving a similar standard-like pronunciation. These unexpected results indicate that regional variation in vowel production in traditionally Swedish-speaking regions in Finland warrants further research.

Possible apparent-time change effects in the production of allophones [øː] and [œː] were examined using the predictor of age with three levels. The interaction between vowel type, style, and age in predicting vowel height indicated that the two younger age groups demonstrated significantly lower normalised values for [œː] in spontaneous speech than speakers aged 56+. Pairwise comparisons also indicated that, in the context of spontaneous speech, the two younger age groups differentiated more between F_1 in allophones [øː] and [œː] than the oldest age group, with the youngest group actually producing higher mean values for [øː] than for [œː]. This inverse pattern is similar to the one found when comparing bilingual and monolingual speakers in the spontaneous speech context. When examining vowel fronting, on the other hand, pairwise comparisons for the interaction of age and vowel type showed that the youngest group produced significantly higher F_2 values for [œː] than the two older groups. The data may thus suggest apparent-time change in the distinction between the allophonic variants [øː] and [œː] in both height and fronting, although the results for the two formants differ. For height, we find significant differences between the two younger groups and the oldest group, and these differences are only found in spontaneous speech. For fronting, on the other hand, there is no interaction effect involving speech style, and the differences are found between the youngest and the two older groups. While both results suggest increased overlap (or, in case of height, even inversion) of the values for the two allophones in younger speakers, further research is required to examine possible change over time.

5. Conclusion

This study, which sought to integrate features of sociolinguistic and bilingual transfer research, examined evidence of decreased distinction between allophones [øː] and [œː] in simultaneous bilingual Finnish and Finland-Swedish speakers. Although the acoustic analysis demonstrated that both monolingual and simultaneous bilingual Finnish and Finland-Swedish participants generally do produce distinct formant frequencies for [øː] and [œː], the results indicate that the distinction is not as pronounced in samples from simultaneous bilinguals. Additionally, in the contexts of spontaneous speech, simultaneous bilinguals are sometimes shown to produce the allophone [œː] in a more closed way than [øː]. The results presented here do not only have implications for the study of interaction between the languages of simultaneous bilinguals, but also for research on the language contact situation in Finland. To date, very few studies have examined vowel production in Finland-Swedish, or used quantitative methods to investigate phonetic transfer between Finnish and Finland-Swedish. Thus, the findigs shed light on ongoing bilingual transfer and phonetic variation in a variety that has, until now, received little attention. By demonstrating the degree to which speakers can vary with regard to allophonic distinction across three speech contexts, our study also highlights the importance of considering speech style when examining cross-linguistic transfer in simultaneous bilinguals. Although more recent studies show an increased use of interviews for obtaining samples of bilingual speech, the majority of research on cross-linguistic transfer continues to be conducted in a single speech style in laboratory settings. This is perhaps due to the main drawback of data collection methods such as the sociolinguistic interview, that is, how time-consuming it is. Indeed, due to the length of the interviews and the high number of participants, only Swedish samples were recorded for the present study. Future research focusing on Finnish and Finland-Swedish transfer would benefit from including comparisons of vowel production in both languages of bilingual speakers, as well as of samples of L1 Finland-Swedish compared with L2 Finnish vowel production.

CRediT authorship contribution statement

Janine A.E. Strandberg: Conceptualization, Methodology, Funding acquisition, Validation, Formal analysis, Investigation, Data curation, Writing - original draft, Visualization. **Charlotte Gooskens:** Supervision, Conceptualization, Methodology, Writing - review & editing. **Anja Schüppert:** Supervision, Conceptualization, Methodology, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

See Tables 11–19.

Appendix B. Reading passage: *Rödluvan*

En gång för länge sedan bodde en liten flicka i en by mitt i skogen. Eftersom flickan alltid gick klädd i en klarröd luva, hade alla i byn glömt vad hon hette och kallade henne bara Rödluvan.

En morgon packade Rödluvans mamma en korg full med nybakat bröd, färskt smör, och en bit rökt kött. “Ta korgen till mormor,” sade mamman till Rödluvan. “Mormor är förkyld och mat kommer att göra henne gott. Men var försiktig då du går i skogen: lämna inte stigen, för då kan du tappa bort dig!”.

Rödluvan klädde på sig sin röda luva och gav sig iväg. Med korgen på armen gick hon genom byn och ut i skogen. Men då Rödluvan gick förbi en björkdunge mötte hon plötsligt en stor grå varg.

“Hej, lilla flicka,” sade vargen. “Vart är du på väg?”

Rödluvan hade aldrig mött en varg förr, och visste inte att hon borde vara rädd. “Jag är på väg till min mormor,” sade Rödluvan. “Hon är förkyld så jag ska föra bröd och smör och kött åt henne.”.

Vargen slickade sig om munnen och log listigt. “Ska du inte plocka några blommor åt din mormor också?” frågade han. “Det växer fina blåsippor där borta som din mormor säkert skulle tycka mycket om.”

Medan Rödluvan stannade för att plocka blåsippor sprang vargen snabbt till mormoderns hus. Där knackade han på dörren och ropade: “Hej, mormor! Det är Rödluvan. Jag har med mig bröd och smör och kött åt dig.”.“Jag är för svag för att öppna dörren,” svarade mormodern. “Lyft haken av dörren och kom in!”

Vargen öppnade dörren och sprang in. Han åt upp mormodern i ett nafs, klädde på sig hennes kläder och drog hennes gröna nattmössa över öronen. Sedan lade han sig i mormoderns säng.

När Rödluvan hade plockat tillräckligt många blåsippor gick hon vidare till mormoderns hus. Hon tyckte att det var konstigt att dörren stod öppen, men ropade ändå: “Hej, mormor, det är Rödluvan! Jag har med mig en korg med bröd, smör och rökt kött!”

Table 11
Overview of participant data according to language background (bilingual and monolingual), age group, and regional background (N = 115).

		18–35 (N = 34)		36–55 (N = 43)		56+ (N = 38)	
		monol.	**bil.**	**monol.**	**bil.**	**monol.**	**bil.**
Helsinki	(N = 40)	7	8	6	7	8	4
S. Finland	(N = 35)	3	4	9	4	11	4
Ostrobothnia	(N = 40)	9	3	9	8	7	4

Table 12
Average number of sample tokens for each participant per vowel per speech context. A total of 4,041 tokens were obtained for 115 participants over two vowels in three speech contexts.

	minimal pairs	reading	spontaneous speech	Total:
close	6.97	4.93	4.99	16.89
open	7.97	4.97	5.33	18.25

Table 13
Target words for sampling in the contexts of (near-) minimal pairs. Narrow transcriptions of expected Finland-Swedish productions and English translations are included. Words included in minimal pairs that were not target words for the current study are marked with an asterisk. Note that the pair *kön–kör* can alternatively be produced as [tɕøːn] 'gender' and [tɕœːr] 'drives'.

Minimal and near-minimal pairs	
bör [bœːr] 'should'	*bär** [bæːr] 'carries'
dög [døːg] 'was fit for'	*dör* [dœːr] 'dies'
kön [køːn] 'the queue'	*kör* [kœːr] 'choir'
öga [øːga] 'eye'	*öra* [œːra] 'ear'
rök [røːk] 'smoke'	*rör* [rœːr] 'pipe'
höna [høːna] 'chicken'	*höra* [hœːra] 'hear'
smör [smœːr] 'butter'	*snör* [snœːr] 'ties'
*säker** [s ɛːkær] 'sure'	*söker* [søːkær] 'sought'

Table 14
Summary for mixed effects model fitted to F_1 production in allophones [øː] and [œː] with random intercepts for subject. The final levels for the factors in the model are the open allophone [œː] (vowel type), spontaneous speech (speech style), monolingual (language), Southern Finland (region), and 56+ (age group).

Fixed effects	Levels	β	SE	t-value	Sig.
(Intercept)		−.01	0.04	−0.14	.886
vowel	close	−.24	0.03	−8.07	<.001
speech style	minimal pairs	−.45	0.04	−10.77	<.001
speech style	reading	.57	0.04	13.61	<.001
language	bilingual	−.02	0.04	−0.42	.674
region	Helsinki	−.05	0.05	−0.87	.387
region	Ostrobothnia	.15	0.05	2.83	.006
age group	18–35	.01	0.06	0.12	.916
age group	36–55	−.04	0.05	−0.79	.431
vowel*style	close, minimal	−.24	0.04	−5.88	<.001
vowel*style	close, reading	−.16	0.04	−3.74	<.001
vowel*language	close, bilingual	.15	0.03	5.07	<.001
style*language	minimal, bilingual	−.06	0.04	−1.53	.126
style*language	reading, bilingual	.08	0.04	2.03	.043
vowel*region	close, Helsinki	−.04	0.04	−0.88	.378
vowel*region	close, Ostrobothnia	−.05	0.04	−1.30	.195
style*region	minimal, Helsinki	−.06	0.06	−1.01	.311
style*region	reading, Helsinki	.01	0.06	0.10	.922
style*region	minimal, Ostrobothnia	.09	0.06	1.59	.112
style*region	reading, Ostrobothnia	.11	0.06	1.94	.054
vowel*age	close, 18–35	.09	0.04	2.22	.027
vowel*age	close, 36–55	−.02	0.04	−0.42	.678
style*age	minimal, 18–35	.06	0.06	0.95	.341
style*age	reading, 18–35	.02	0.06	0.31	.756
style*age	minimal, 36–55	−.04	0.06	−0.78	.435
style*age	reading, 36–55	.07	0.06	1.25	.214
vowel*style*language	close, minimal, bilingual	−.01	0.04	−0.32	.756
vowel*style*language	close, reading, bilingual	−.09	0.04	−2.18	.030
vowel*style*region	close, minimal, Helsinki	−.03	0.06	−0.55	.581
vowel*style*region	close, reading, Helsinki	−.06	0.06	−1.06	.290
vowel*style*region	close, minimal, Ostrobothnia	.05	0.06	0.87	.384
vowel*style*region	close, reading, Ostrobothnia	.04	0.06	0.67	.505
vowel*style*age	close, minimal, 18–35	−.08	0.06	−1.37	.171
vowel*style*age	close, reading, 18–35	.02	0.06	0.32	.751
vowel*style*age	close, minimal, 36–55	.05	0.06	0.85	.399
vowel*style*age	close, reading, 36–55	−.12	0.06	−2.11	.035

Table 15
Summary for mixed effects model fitted to F_2 production in allophones [øː] and [œː] with random intercepts for subject. The final levels for the factors in the model are the open allophone [œː] (vowel type), spontaneous speech (speech style), monolingual (language), Southern Finland (region), and 56+ (age group).

Fixed effects	Levels	β	SE	t-value	Sig.
(Intercept)		.02	0.02	1.26	.212
vowel	close	.81	0.01	55.29	<.001
speech style	minimal pairs	.13	0.02	6.41	<.001
speech style	reading	−.22	0.02	−10.63	<.001
language	bilingual	.08	0.02	4.95	<.001
region	Helsinki	−.01	0.02	−0.64	.526
region	Ostrobothnia	−.01	0.02	−0.47	.639
age group	18–35	.12	0.02	4.83	<.001
age group	36–55	−.01	0.02	−0.36	.722
vowel*style	close, minimal	.30	0.02	14.45	<.001
vowel*style	close, reading	−.02	0.02	−0.95	.343
vowel*language	close, bilingual	−.13	0.01	−8.58	<.001
style*language	minimal, bilingual	−.02	0.02	−1.14	.253
style*language	reading, bilingual	.04	0.02	2.01	.045
vowel*region	close, Helsinki	.12	0.02	6.02	<.001
vowel*region	close, Ostrobothnia	−.21	0.02	−10.30	<.001
style*region	minimal, Helsinki	.01	0.03	0.26	.795
style*region	reading, Helsinki	−.03	0.03	−0.99	.323
style*region	minimal, Ostrobothnia	.04	0.03	1.32	.188
style*region	reading, Ostrobothnia	.01	0.03	0.22	.828
vowel*age	close, 18–35	−.13	0.02	−5.94	<.001
vowel*age	close, 36–55	.08	0.02	4.02	<.001
vowel*style*language	close, minimal, bilingual	.04	0.02	2.15	.032
vowel*style*language	close, reading, bilingual	−.00	0.02	−0.17	.866
vowel*style*region	close, minimal, Helsinki	.07	0.03	2.56	.011
vowel*style*region	close, reading, Helsinki	.00	0.03	0.07	.948
vowel*style*region	close, minimal, Ostrobothnia	−.10	0.03	−3.69	<.001
vowel*style*region	close, reading, Ostrobothnia	−.02	0.03	−0.54	.589

Table 16
Mean normalised F_1 and F_2 Hz values for the long close vowel [øː] according to the between-subject factor levels of language, region, and age in the within-subject factor levels of speech style.

vowel	style				F1	F2	N
close	minimal pairs				391	1703	115
	reading				423	1593	114
	spontaneous speech				418	1605	115
vowel	style	language			F1	F2	N
close	minimal pairs	bilingual			393	1702	46
		monolingual			390	1704	69
	reading	bilingual			426	1594	46
		monolingual			420	1592	68
	spontaneous speech	bilingual			426	1586	46
		monolingual			413	1617	69
vowel	style		region		F1	F2	N
close	minimal pairs		Helsinki		387	1733	40
			S. Finland		389	1719	35
			Ostrobothnia		398	1658	40
	reading		Helsinki		419	1606	40
			S. Finland		419	1617	34
			Ostrobothnia		429	1558	40
	spontaneous speech		Helsinki		421	1611	40
			S. Finland		421	1620	35
			Ostrobothnia		413	1584	40
vowel	style			age	F1	F2	N
close	minimal pairs			18–35	393	1692	34
				36–55	391	1717	43
				56+	390	1697	38
	reading			18–35	427	1588	34
				36–55	420	1602	43
				56+	421	1586	37
	spontaneous speech			18–35	421	1611	34
				36–55	418	1606	43
				56+	416	1598	38

Table 17
Mean normalised F_1 and F_2 Hz values for the long open vowel [œ:] according to the between-subject factor levels of language, region, and age in the within-subject factor levels of speech style.

vowel	style				F1	F2	N
open	minimal pairs				421	1335	115
	reading				447	1326	114
	spontaneous speech				412	1418	115
vowel	style	language			F1	F2	N
open	minimal pairs	bilingual			413	1363	46
		monolingual			426	1317	69
	reading	bilingual			448	1375	46
		monolingual			447	1293	68
	spontaneous speech	bilingual			401	1465	46
		monolingual			420	1387	69
vowel	style		region		F1	F2	N
open	minimal pairs		Helsinki		419	1310	40
			S. Finland		415	1303	35
			Ostrobothnia		428	1389	40
	reading		Helsinki		448	1309	40
			S. Finland		437	1307	34
			Ostrobothnia		455	1359	40
	spontaneous speech		Helsinki		409	1422	40
			S. Finland		414	1409	35
			Ostrobothnia		413	1422	40
vowel	style			age	F1	F2	N
open	minimal pairs			18–35	423	1384	34
				36–55	418	1325	43
				56+	423	1302	38
	reading			18–35	445	1372	34
				36–55	452	1320	43
				56+	443	1291	37
	spontaneous speech			18–35	405	1452	34
				36–55	408	1413	40
				56+	423	1393	38

Table 18
Summary of pairwise comparison of normalised F_1 values with the contrast of vowel type and the predictors of language background and speech style.

style	language	contrast	estimate	SE	df	t-ratio	Sig.
minimal	bilingual	close – open	−0.69	0.16	543	−4.35	<.001
pairs	monolingual	close – open	−1.23	0.13	543	−9.62	<.001
reading	bilingual	close – open	−0.67	0.16	543	−4.22	<.001
	monolingual	close – open	−0.90	0.13	543	−6.99	<.001
spontaneous	bilingual	close – open	0.83	0.16	543	5.26	<.001
speech	monolingual	close – open	−0.18	0.13	543	−1.42	.156

Table 19
Summary of pairwise comparison of normalised F_1 values with the contrast of vowel type and the predictors of speech style and age group.

style	age group	contrast	estimate	SE	df	t-ratio	Sig.
minimal	18–35	close – open	−0.94	0.18	543	−5.08	<.001
pairs	36–55	close – open	−0.90	0.16	543	−5.55	<.001
	56+	close – open	−10.45	0.18	543	−5.94	<.001
reading	18–35	close – open	−0.56	0.18	543	−3.03	.003
	36–55	close – open	−10.52	0.16	543	−6.49	<.001
	56+	close – open	−0.74	0.18	543	−4.16	<.001
spontaneous	18–35	close – open	0.64	0.18	543	3.46	<.001
speech	36–55	close – open	0.43	0.16	543	2.68	.008
	56+	close – open	−0.10	0.18	543	−0.56	.579

Då hon inte fick något svar steg Rödluvan in genom dörren och gick fram till mormoderns säng. Hon såg sin mormor som låg i sängen med nattmössan över ansiktet och tyckte att den gamla gumman såg lite underlig ut.

"Mormor!" utbrast Rödluvan. "Vilka konstiga öron du har!"

"Desto bättre hör jag dig," svarade en mörk röst.

"Men mormor, vilka stora ögon du har!" sade Rödluvan.

"Desto bättre ser jag dig, lilla vän," sade rösten.

"Men mormor, vilka stora händer du har!"

"Desto bättre kan jag krama dig."

Till sist tittade Rödluvan på de stora vita tänderna som stack fram under den gröna nattmössan och utbrast: "Mormor, vilken förskräckligt stor mun du har!"

"Desto lättare kan jag äta upp dig!" röt vargen och slukade Rödluvan.

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