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Child-directed Speech in a Norwegian Kindergarten Setting

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ABSTRACT
This paper presents a natural experiment using a play situation with specific toys to examine and compare the characteristics of 33 Norwegian-speaking female pedagogical employees' child-directed speech (CDS) and adult-directed speech (ADS). Vowel pitch, duration, format frequency, and vowel space area of the vowels /a:/, /i:/, and /u:/ as well as their short counterparts /a/, /i/, and /u/ were analyzed. One-way repeated-measures ANOVAs show that the pedagogical employees spoke with a higher vowel pitch, had greater variation in their vowel pitch, and had smaller vowel space areas in CDS compared with ADS. In addition, the vowels in CDS were hypoarticulated compared with ADS. Therefore, the pedagogical employees enhanced CDS characteristics associated with attaining children's attention and promoting social interaction between child and caregiver.

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Child-directed speech; infant-directed speech; vowels; pitch; vowel space; hypoarticulation

Introduction

Adaptations in the way adults speak to children are known as child-directed speech (CDS). According to Fernald (1992) and Golinkoff et al. (2015), CDS aids linguistic development by attaining children's attention, fostering social interaction between child and caregiver, and conveying specific linguistic and phonological information. The characteristics and effects of mothers' and fathers' CDS has been explored extensively (Broesch & Bryant, 2013, 2018; Farran et al., 2016; Gergely et al., 2017; Kitamura et al., 2001). However, research on CDS in contexts outside the family, such as educational contexts, is limited and the role of other language models, such as pedagogical employees in kindergartens, is underexplored in the Norwegian context.

Language acquisition studies conducted in Norwegian kindergartens include studies on the effect of age of enrollment and total time spent on children's language development. Lekhal et al. (2011) found that children enrolled in family daycare and kindergartens at 18 months of age had a lower prevalence of late speaking at three years of age compared with children kept at home with their parents. The effect remained after controlling for socio-economic background variables and early social communication skills before entering childcare. Similarly, Zachrisson et al. (2013) revealed that boys' conceptual understanding at four years of age, tested using a Norwegian translation of the British Picture Vocabulary Scale (Dunn et al., 1997), varied significantly as a function of parent-reported total time spent in kindergarten, with higher time expenditure correlated with higher conceptual understanding. Both studies indicate that the amount of time spent in the kindergarten before the age of four is positively correlated with language outcomes, suggesting that the language stimulation children receive in the kindergarten is an important contribution to their language acquisition.

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In Norway, 92% of preschool children are enrolled in kindergartens (Statistics Norway, 2020b). Since the availability of universal child care from one year of age became a political priority in Norway in 2009 (Norwegian Ministry of Education and Research, 2015), the percentage of one- to two-year-old children (toddlers) enrolled in kindergarten has steadily increased from 77% in 2018 (Statistics Norway, 2018) to 84% in 2020 (Statistics Norway, 2020b). The majority of these toddlers spend 41 h or more in the kindergarten during the work week (Statistics Norway, 2018). Although toddlers often nap in the kindergarten, one may assume that on average, Norwegian toddlers spend more hours awake together with pedagogical employees than with their parents during the work week.

One may assume that kindergartens foster children's language acquisition by providing children with higher quantities of language input through interaction with both peers and non-parent adults. However, Golinkoff et al. (2015) and Gramann and Torkildsen (2016) pointed out that both the quantity and quality of language input are important in a child's language acquisition process. A Scandinavian review by Sandvik et al. (2014) revealed that research on the quality of kindergarten employees' language in interaction with toddlers centers around language content. While these studies provide some important insights, the more fine-grained aspects of ambient language and speech directed toward toddlers in kindergarten require further investigation. Examining the CDS of pedagogical employees in interaction with toddlers can provide important insight into the characteristics of the stimuli from which toddlers learn during an extensive amount of time weekly.

The characteristics of vowels in the CDS of mothers and fathers have been extensively analyzed (Broesch & Bryant, 2013, 2018; Farran et al., 2016; Gergely et al., 2017; Kitamura et al., 2001). Moreover, the corner vowels /a/, /i/, and /u/ have received particular attention (Bender, 2013; Englund & Behne, 2005; Liu et al., 2003). These vowels occur in many of the world's languages and represent articulatory extremes (Kristoffersen, 2000; Liljencrants & Lindblom, 1972), constituting an articulatory frame of reference. Investigating adaptations in the acoustic-phonetic characteristics of corner vowels in the speech of pedagogical employees in interaction with toddlers provides the opportunity to examine characteristics such as prosody, pitch/fundamental frequency (F0) height and variation, and vowel duration.

Golinkoff et al. (2015) hypothesized that CDS with greater variability and reflection of positive emotions through a higher pitch triggers infants' attention. Zangl and Mills (2007) demonstrated increased brain activity in six- and 13-month-old infants in response to CDS compared with ADS and argued that language learning may be guided by keeping children focused on the linguistic signal. In addition, Kaplan et al. (2002) found that pitch variation in the CDS of depressed mothers did not reflect positive emotions and that infants were less likely to engage in associative learning necessary for language development when exposed to CDS from depressed mothers compared with typical pitch variations. These finding indicate that adjusting the CDS pitch may affect children's language acquisition process.

Sundberg (1998) proposed that exaggeration in the durational difference between long and short vowels in CDS makes phonological differences more salient to children, thereby guiding the learning of the differences. In Norwegian, vowel quantity is a phonological distinction revealed in the difference between long and short vowels (Behne et al., 1996; Kristoffersen, 2000). This implies that each vowel quality in the phonetic inventory includes long and short versions. Englund and Behne (2006) discovered that vowel duration was generally longer for Norwegian mothers' CDS than for their ADS. Furthermore, Song et al. (2010) found that prolonged duration and a slower speaking rate facilitate infants' ability to recognize words.

According to the hyperarticulation hypothesis, challenged by Cristia and Seidl (2013), like adaptations in vowel duration, format frequency alterations of the corner vowels in CDS may guide the learning of vowel categories. As described by Englund and Behne (2019), the nature of speech is such that it varies along a scale of hyper- and hypoarticulation. The perceived necessity for clear speech to convey a message to a receiver determines the degree to which speech becomes hyper- or hypoarticulation. There is no direct correlation between formant frequency and articulatory movement; however, in line with the hyperarticulation hypothesis, a lower third formant frequency (F3) for rounded vowels, such as /u/, is likely to make them easier to separate from unrounded vowels due to F3's inverse relation to lip protrusion (Kent & Read, 1992; Stevens, 1998), simplifying the learning of vowel categories.

Furthermore, a vowel can be symbolized as a point in a 3D space, known as the vowel space area, defined by its first (F1) and second formant frequency (F2). Although not evident in all studies (Bender, 2013; Englund & Behne, 2006), various languages exhibit a larger vowel space area in CDS compared with ADS (Burnham et al., 2002; Kuhl et al., 1997; Liu et al., 2003). As described by Cristia and Seidl (2013), the hyperarticulation hypothesis postulates that a greater vowel space area in CDS makes vowel distinctions more salient. Liu et al. (2003) examined the correlation between maternal speech clarity, measured as the degree of expansion of the vowel space, and infant speech perception performance, measured with a head turn-task, and found that vowel space size in mothers' CDS was positively correlated with six- to 12-month-old infants' ability to differentiate vowels, demonstrating that this adaptation can guide the learning of vowel categories.

The Present Study

The above studies indicate that adaptations in acoustic-phonetic characteristics of the corner vowels in CDS can aid children's language acquisition process. The present study compares the variations in the acoustic-phonetic characteristics of the vowels /a:/, /a/, /i:/, /i/, /u:/, and /u/ in the CDS of Norwegian female pedagogical kindergarten employees compared with their ADS. This study aims to reveal the qualitative characteristics of the linguistic learning environment in Norwegian kindergartens that may affect toddlers' language development.

This study presents a natural experiment using recordings of kindergarten employees interacting with toddlers. Based on previous research and the CDS theory, we expect vowel pitch to be higher and pitch ranges to be wider in CDS compared with ADS for all six vowels. In addition, we predict that vowel duration in general will be longer in CDS compared with ADS or that CDS will display an extended vowel quantity distinction (difference between long and short vowels) through an additional increase in the duration of long vowels. Vowel space areas in CDS are expected to be larger than in ADS. We also predict that the rounded vowels /u:/ and /u/ will have lower third format frequencies in CDS compared with ADS, while the unrounded vowels /a:/, /a/, /i:/, and /i/ will have higher frequencies.

Materials and Methods

Design

This study used a natural quasi-experimental factorial design to investigate CDS and ADS production of 33 female pedagogical employees. The participants' speech was recorded in two settings (CDS and ADS), resulting in 66 recordings. Speech type (CDS and ADS) and vowels (/a:/, /a/, /i:/, /i/, /u:/, and /u/) were used as the independent variables. Fundamental frequency (F0) means, F0 range means, duration, vowel space area, and the three first formant frequencies (F1–F3) were used as dependent variables.

Recruitment and Participants

Acoustic-phonetic content of CDS may vary depending on the speaker's gender (Broesch & Bryant, 2018; Warren-Leubecker & Bohannon, 1984) and language (Farran et al., 2016; Kitamura et al., 2001). The majority of pedagogical employees in Norwegian kindergartens are females (Statistics Norway, 2020a) and with Norwegian as first language. As this study aimed to display the general characteristics of the CDS that toddlers in Norwegian kindergartens are exposed to, only female pedagogical employees with Norwegian as their first language and working with toddlers were included as participants.

Potential participants were recruited and briefed about the project through information meetings at seven kindergartens. In total, 33 gave their informed consent to participate in the study. Their mean age was 38.7 years (23–65) and they had worked an average of 13.4 years (1–39) in kindergarten. Their educational background ranged from having no higher education related to childcare and pedagogy to holding master's degrees in pedagogical subjects. The majority (20) had a bachelor's degree in preschool/kindergarten education. Six participants spoke a Central Norwegian dialect, three spoke Western Norwegian, two spoke Northern Norwegian, and one spoke Eastern Norwegian.

The Children

Children taking part in research are entitled to special protection (The Norwegian National Committees for Research Ethics, 2016). The participants only interacted with toddlers that they cared for on a daily basis, those who had an attachment to the participants. A total of 31 children took part in the study, including 19 girls (two girls interacted with two participants each) and 12 boys. The mean age of the children was 24.3 months (10–34), with 24.2 months (10–31) for girls and 24.4 months (13–34) for boys. The majority (26) of the children had monolingual Norwegian parents. Two boys had Arabic-speaking parents, two bilingual girls had one Norwegian- and one Arabic-speaking parent, and one bilingual girl had one Norwegian- and one Russian-speaking parent. Based on parental reports, all the children were considered healthy without any reported visual or hearing problems. Written information was distributed to parents one week before data collection and oral consent was provided by parents. The present study was approved by Norwegian Centre for Research Data (NSD).

Procedure and Sound Equipment

This study used speech recordings of the participants' interaction with toddlers in the kindergartens where they worked. This allowed for toddlers and the caregivers to be alone in a familiar room while making the CDS recordings. ADS recordings were obtained in familiar settings, promoting relaxed adult conversations.

Each participant was recorded during two sessions. During CDS recordings, participants were asked to use and mention six specific toys provided by the experimenter: a plush cake (/ka:ke/), a plush cat (/kat:/), a plush tiger (/ti:ger/), a Pippi Longstocking doll (/pip:i/), a touch-and-feel book (/bu:k/), and a wooden billy goat (/buk:/). The participants were instructed to otherwise interact with the toddlers normally. The participants chose the room for the CDS recordings based on availability, suitability, and what the toddler was familiar with. The rooms varied from open space play areas (approximately 20 m^2) to smaller group rooms (approximately 9 m^2). Additional to being in a room alone with the toddler to ensure good quality recordings, noisy toys, such as musical instruments, were removed, and the windows were closed. The majority of ADS recordings were conducted in the same room as CDS recordings, with 13 recordings conducted in the kindergarten lunchrooms. During ADS recordings, the participants talked to the same experimenter that hosted the information meetings. Each participant was encouraged to talk about their interaction with the toddler during the CDS recordings, ensuring that the names of the toys were repeated.

Each participant wore a t-shirt with a chest pocket containing a recorder in order to ensure a constant distance between the mouth and the recorder. The LENA digital language processor (DLP) was used for the recordings (LENA, 2018a). Recording duration varied from four to 29 min with a mean of 18 min for CDS and nine for ADS. LENA pro (LENA, 2018b) was used to transfer the audio recordings from the DLP to a computer and convert them to audio files in the wav format.

Acoustic Analyses

Surrounding segments affect quality and vowel duration (Englund, 2005; Kent & Read, 1992; Slethei et al., 2017; Stevens, 1998). To reduce noise, we focused on a limited set of phonetic environments. The sound-editing program PRAAT (Boersma & Weenink, 2016) was used to edit files, selecting all occurrences of the toy words. Vowels (/a:/, /a/, /i:/, /i/, /u:/, and /u/) were segmented from these occurrences, following the selection criterium of no background noise. Vowels were excluded if they could not be distinguished visually or auditorily due to interference, such as voice overlap, or if formant frequencies were not visible in the spectrogram. This resulted in a total of 1604 vowels that could be acoustically analyzed from the CDS recordings and 584 from the ADS recordings.

Visual examination of the spectrogram and auditory interpretation of the sound clip were used to identify the outer boundaries of a target vowel. Fundamental frequency (F0), first, second and third formant frequency (F1–F3), and duration were calculated by PRAAT for each vowel. F0–F3 were calculated in Hertz (Hz) based on the mean of the selected area between the outer boundaries of a target vowel. Duration of each vowel was calculated in milliseconds based on the total selected area.

Results

Version 25 of the SPSS statistical package was used for all statistical operations. Before statistical analyses, F0–F3 values measured in Hz were recalculated according to the Mel scale, which includes the nonlinearity of the perception of frequency (Stevens et al., 1937). O'Shaughnessy's (1999) formula, $m = 2595 \log 10\ (1 + f/700)$, was used for recalculations.

For 11 participants, data were missing for two vowels, while for one participant, data were missing for three vowels. This was due to absence of occurrences or occurrences being unsuitable for acoustic analyses for some toy names. Missing values were replaced with the pooled values after five imputations. Following the imputation, the data were aggregated to create means for the independent variables, speech type (CDS and ADS) and vowels (/a:/, /a/, /i:/, /i/, /u:/, and /u/), for each of the 33 participants. One-way repeated-measures ANOVAs, with speech type and vowels as independent variables and F0 means, F0 range means, duration, vowel space, and F1–F3 as dependent variables, were performed with the aggregated and reconstructed dataset. A 5% significance level was applied throughout the analyses and Bonferroni correction was used for the post hoc tests to decrease the likelihood of a type-I error.

Vowel Pitch (F0) Mean

The main analysis showed a statistically significant difference in the F0 means, $F(6.59, 211) = 13.65$, $p < .001$, partial $\eta^2 = .299$. Mauchly's test indicated that the assumption of sphericity had been violated, $x^2(11) = 111$, $p < .001$. Therefore, the Greenhouse-Geisser correction was used ($\varepsilon = .599$). Post hoc tests revealed that the F0 means for /a:/, /i/, /u:/, and /u/ in CDS compared with the F0 means of the same vowels in ADS were significantly higher (see Table 1 for mean differences, *p*-values and

Table 1. Pairwise comparison of mean pitch (F0) and mean F0 range measured in Mel for the corner vowels in child-directed speech (CDS) and adult-directed speech (ADS).

	Mean F0					Mean F0 range				
	CDS	ADS	Mean difference	SE	Sig.	CDS	ADS	Mean difference	SE	Sig.
/a:/	352	305	46.9	10.5	.006	309	127	181	22.4	.001
/a/	381	334	47.3	15.2	.26	290	124	166	20.3	.001
/i:/	338	296	41.6	11.9	.091	272	110	162	23.4	.001
/i/	389	336	53.6	12.8	.014	246	118	127	24.6	.001
/u:/	351	291	59.8	13.1	.005	246	125	121	21.3	.001
/u/	366	317	49.1	12.8	.036	257	124	133	21.1	.001

standard error). No significant differences in the F0 means for /a/ and /i:/ were found across speech types.

Vowel Pitch (F0) Range

The main analysis showed a statistically significant difference in F0 range means, $F(7.28, 233) = 25.6$, $p < .001$, partial $\eta^2 = .881$. Mauchly's test indicates that the assumption of sphericity had been violated, $x^2(11) = 87.4$, $p = .038$. Therefore, the Greenhouse-Geisser correction was used ($\varepsilon = .661$). Post hoc tests revealed that for all the vowels, the mean range was significantly wider in CDS compared with ADS (see Table 1 for mean differences, p-values, and standard error).

Duration

Duration is perceived logarithmically (Allen & Gibbon, 1991). Therefore, a logarithmic transformation into duration values was applied. Table 2 shows vowel duration and standard deviation, presented in milliseconds. Log values were used for statistical analyses. The main analysis showed a statistically significant difference in the vowel duration log means, $F(6.79, 217) = 72.8$, $p < .001$, partial $\eta^2 = .984$. Mauchly's test indicated that the assumption of sphericity had been violated, $x^2(11) = 93$, $p = .015$. Therefore, the Greenhouse-Geisser correction was used ($\varepsilon = .617$). Post hoc tests revealed no significant differences in vowel duration for the same vowels across speech types (see Table 2 for mean differences, p-values, and standard error).

Table 2. Vowel duration for the corner vowels for child-directed speech (CDS) and adult-directed speech (ADS) measured in milliseconds (SD) and pairwise comparison of mean vowel duration after Log transformation in CDS and ADS.

	Milliseconds		Log				
	CDS (SD)	ADS (SD)	CDS	ADS	Mean difference	SE	Sig.
/a:/	111(25)	111(28.6)	4.61	4.64	−.032	.06	1
/a/	62.4(15.2)	54.9(20.8)	4.08	3.97	.11	.05	1
/i:/	155(59)	114(25.9)	4.9	4.69	.209	.076	.662
/i/	64.6(15.3)	59.1(14.2)	4.1	4.01	.084	.054	1
/u:/	115(32)	114(36.1)	4.61	4.64	−.028	.066	1
/u/	58.3(13.7)	59.4(15.7)	4	4.02	−.019	.054	1

Vowel Space Area

Vowel space areas were calculated separately for long (/a:/, /i:/, and /u:/) and short vowels (/a/, /i/, and /u/) and for CDS and ADS. Vowel space area refers to the size of the area within the lines drawn between the vowels /a:/, /i:/, and /u:/ and /a/, /i/, and /u/ (see Fig. 1 and 2). The areas were calculated in SPSS using the formula described in Liu et al. (2003): vowel space = {[F1i*(F2a − F2u) + F1a*(F2u − F2i) + F1u*(F2i − F2a)]/2}, where F1i is the first format frequency for vowel sets such as /i:/ or /i/.

As Figures 1 and 2 demonstrate, for both vowel quantities, vowel space areas are greater for ADS than for CDS. The main analysis showed a statistically significant difference in the size of the vowel space areas, $F(3, 96) = 13.2$, $p < .001$, $\eta^2 = .292$. Mauchly's test indicated that the assumption of sphericity had been met, $x^2(5) = 4.65$, $p = .46$. Post hoc tests revealed that for long vowels, the vowel space area for ADS ($\mu = 296791$, $SD = 79419$) was significantly larger than the vowel space area for CDS ($\mu = 215328$, $SD = 76014$, $p < .001$). The same was found for short vowels, with the vowel space area for ADS ($\mu = 249572$, $SD = 76687$) significantly larger than that for CDS ($\mu = 199783$, $SD = 63201$, $p = .012$).

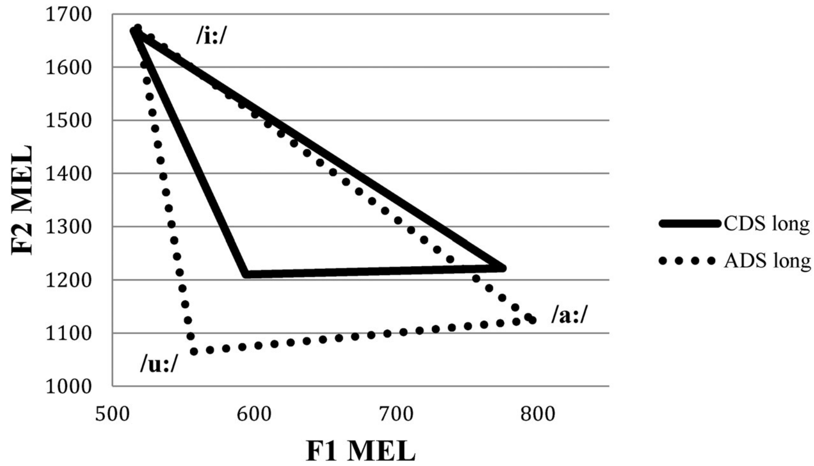

Figure 1. Vowel space areas measured in Mel for long vowels in child-directed speech (CDS) and adult-directed speech (ADS).

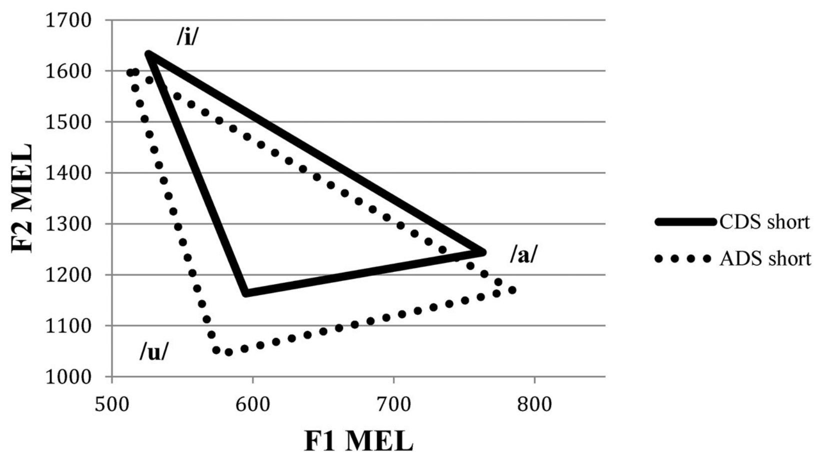

Figure 2. Vowel space areas measured in Mel for short vowels in child-directed speech (CDS) and adult-directed speech (ADS).

First Format Frequency (F1)

The main analysis shows a statistically significant difference in the F1 means, $F(7.11, 228) = 189$, $p < .001$, partial $\eta^2 = .855$. Mauchly's test indicated that the assumption of sphericity had been violated, $x^2(11) = 100$, $p < .001$. Therefore, the Greenhouse-Geisser correction was used ($\varepsilon = .647$). Post hoc tests revealed no significant differences in the F1 means for the same vowels across speech types (see Table 3 for mean differences, standard error, and p-values).

Second Formant Frequency (F2)

The main analysis showed a statistically significant difference in the F2 means, $F(6.29, 201) = 135$, $p < .001$, partial $\eta^2 = .808$. Mauchly's test indicated that the assumption of sphericity had been violated, $x^2(11) = 174$, $p < .001$. Therefore, the Greenhouse-Geisser correction was used ($\varepsilon = .572$). Post hoc tests revealed that the F2 means for /a:/ and /u:/ in CDS compared with that for ADS were significantly higher (see Table 3 for mean differences, standard error, and p-values). There were no other significant differences in the F2 means for the same vowels across the speech types.

Table 3. Pairwise comparison of mean first (F1) and mean second formant frequencies (F2) measured in Mel for the corner vowels in child-directed speech (CDS) and adult-directed speech (ADS).

	F1					F2				
	CDS	ADS	Mean difference	SE	Sig.	CDS	ADS	Mean difference	SE	Sig.
/a:/	775	796	−20.8	9.68	1	1222	1124	98.2	14.7	.001
/a/	763	784	−20.8	14	1	1244	1170	73.6	31.7	1
/i:/	515	518	−2.7	5.96	1	1668	1674	−5.59	17.9	1
/i/	526	512	14.4	10.5	1	1633	1605	27.3	16.8	1
/u:/	594	557	37.1	11	.13	1210	1065	146	38.6	.043
/u/	595	575	19.8	15	1	1163	1043	120	42.8	.564

Third Formant Frequency (F3)

The main analysis showed a significant difference in the F3 means, $F(6.72,\ 215) = 29.5$, $p < .001$, partial $\eta^2 = .48$. Mauchly's test of sphericity indicated that the assumption of sphericity had been violated, $x^2(11) = 108$, $p < .001$. Therefore, the Greenhouse-Geisser correction was used ($\varepsilon = .611$). Post hoc tests revealed that the F3 mean for /a:/ in CDS was significantly higher than that for ADS (see Table 4 for mean differences, standard error, and *p*-values). There were no other significant differences in the F3 means for the same vowels across speech types.

Table 4. Pairwise comparison of mean third formant frequencies (F3) measured in Mel for the corner vowels in child-directed speech (CDS) and adult-directed speech (ADS).

	F3				
	CDS	ADS	Mean difference	SE	Sig.
/a:/	1835	1781	53.8	9.77	.001
/a/	1879	1849	29.5	13.5	1
/i:/	1952	1932	19.6	9.46	1
/i/	1925	1889	36.9	12.2	.33
/u:/	1893	1870	22.9	10.5	1
/u/	1881	1848	32.9	13.3	1

Discussion

Vowel Pitch Mean and Range

Mean pitch was higher for /a:/, /i/, /u:/, and /u/ and pitch range means were wider for all vowels in CDS compared with ADS. This is in line with previous findings across cultures, languages, and settings (Broesch & Bryant, 2013; Kitamura et al., 2001). According to Golinkoff et al. (2015), a child learning a language must be able to attend to and differentiate speech from other sounds in order to acquire language. Fernald and Kuhl (1987) argue that adaptations in prosody, such as higher pitch and greater variation in pitch, make infants prefer CDS over ADS (Dunst et al., 2012; Fernald, 1985). In a label production study, Estes and Hurley (2013) found that 17-month-old children succeeded in learning labels produced in CDS but failed to learn the same labels produced in ADS. Further, they found that variability in prosody of CDS could explain these findings, indicating that this may facilitate children's vocabulary acquisition.

Fernald (1992) suggests that pitch modifications found in CDS are an evolutionary trait designed to comfort a child. Similarly, pitch changes were found in pet directed speech (Burnham et al., 2002) but not in speech directed toward second language learners (Biersack et al., 2005; Uther et al., 2007). This further suggests that pitch modifications in CDS are related to affection. The participants' use of positive intonation, characterized by higher mean pitch, could be an unconscious way of making the toddlers feel comfortable in the play-situation.

According to Høigård (2013), use of high pitch in CDS is associated with acknowledging a child's contributions to the verbal interaction. Children start to produce their first words around 12 months of age and understanding and production of words increase rapidly in the second and third year of life (Gramann & Torkildsen, 2016). In interactions with children through this age span, it is natural for caregivers to encourage children to utter known and new words. Thus, the participants may have been trying to motivate the toddlers to express the names of the toys and acknowledging the toddlers' effort by using a high pitch.

Adaptations in pitch can have a positive effect on a toddlers' language acquisition and may partially explain the positive correlation between time spent in Norwegian kindergartens and language development (Lekhal et al., 2011; Zachrisson et al., 2013). Thus, exposure to CDS in the kindergarten can be especially important for children with primary caregivers who do not display these adaptations in their CDS (Kaplan et al., 2002).

Duration

The findings show that durational differences between long and short vowels were equivalent across speech types, diverging from the prediction. Sundberg (1998) studied Swedish CDS, which is comparable to Norwegian CDS, and found that the vowel quantity contrast in mothers' CDS toward their three-month-old infants was exaggerated by increased vowel duration for long vowels compared to short vowels. Sundberg (1998) suggested that this creates differences between vowel quantities (long and short) with the same corner vowel quality (/a:/-/a/, /i:/-/i/, and /u:/-/u/) more auditorily salient to a child, guiding the learning of this phonetic contrast. According to Lindblom (1967), vowel duration is associated with the transfer of important language-specific differences from language models to learners. Thus, an exposure to increased vowel quantity distinction could prove beneficial only for children still acquiring language-specific vowel differences and prove unnecessary for others. Narayan and McDermott (2016) and Song et al. (2010) found that adaptations in caregivers' CDS were affected by the development of the child they interact with. Sundberg's (1998) sample was considerably younger than the toddlers in this study who have had more time to master vowel quantity differences.

Contrary to our predictions, female pedagogical employees did not extend their vowel duration in CDS compared with ADS. Prolonged vowel duration found in previous studies on CDS could be the result of a generally slower speaking rate in CDS than in ADS. Song et al. (2010) pointed to studies consistently showing a slower speaking rate in CDS across different languages, speakers, and settings. Although not explicitly measured, the findings of the present study suggest that Norwegian female pedagogical employees do not speak slower to toddlers than with adults. Age may be of interest, with slow speech rate being more used in CDS with younger infants. Narayan and McDermott (2016) studied the CDS of Sri Lankan Tamil (SLT), Tagalog, and Korean mothers and found that mothers steadily increased their speech rate over the course of 12 months as infants aged from four to 16 months. Narayan and McDermott (2016) also discovered that the speech rate varied across the languages. This points to both age- and language-dependent characteristics in the present CDS.

Slow speaking rate in CDS was found to significantly improve infants' ability to recognize words (Song et al., 2010), while time spent in the kindergarten was found to positively correlate with language outcome (Lekhal et al., 2011; Zachrisson et al., 2013). We must consider the possibility that the employees in the present CDS sample did not intend to aid word learning (Golinkoff et al., 2015). However, slow speaking rate might be an adaptation in pedagogical employees' CDS present in other situations.

Vowel Space Area

According to Cristia and Seidl (2013), the predominant hyperarticulation hypothesis suggests that learning of vowel categories may be facilitated by exaggerating the distance contrast between the corner vowels in the vowel space, making the vowels from a larger vowel space area in CDS easier to learn from. Kuhl et al. (1997) found evidence for a larger vowel space area in maternal CDS, indicating that this may be a universal trait of CDS. The results of this study are contrary to this, showing a smaller vowel space area for both vowel quantities in CDS compared with ADS. These results are in line with Bender (2013), who found that vowel space areas were smaller in maternal CDS compared with ADS. There are a few studies, including the current one, that involve children older than in most previous studies on vowel space area (Kuhl et al., 1997; Liu et al., 2003). This indicates that an enlarged vowel space area may only be a characteristic of CDS for preverbal children. This explanation is supported by evidence of children's ability to distinguish language-specific vowel differences at six months of age (Kuhl et al., 1992). As with vowel duration, one could argue that it was unnecessary for the female pedagogical employees to enhance their vowel space area for children around 12 months of age and above, as they are likely sufficiently familiar with the vowels of their first language, making vowel space area a characteristic of CDS irrelevant for language learning in kindergartens.

However, this argument is weakened by the finding of significantly smaller vowel space areas in Norwegian CDS for infants compared with ADS. In face-to-face interactions with their infants during the first six months of life, Norwegian mothers showed narrowed vowel spaces in CDS compared with ADS (Englund & Behne, 2006). This indicates that hyperarticulation of corner vowels is not a characteristic of female Norwegian CDS. Similar to Kitamura et al. (2001) and Narayan and McDermott (2016), the findings of the present study further underpin the assumption that acoustic-phonetic characteristics of CDS in general are language-specific to a larger degree than originally assumed.

First- (F1), Second- (F2) and Third Formant Frequency (F3)

The relationship between format frequencies and articulatory movement is indirect; however, in general, F1 is associated with vertical position of the tongue body in the oral cavity and degree of openness in articulation (Kent & Read, 1992; Stevens, 1998). The vowels /a:/ and /a/ are more open than /i:/, /i/, /u:/, and /u:/ (Kristoffersen, 2000). According to the hyperarticulation hypothesis, F1 for the open vowels is increased in CDS compared with ADS. Although the findings were not statistically significant, the opposite was found in the present study.

F2 corresponds to horizontal placement of the tongue body in the oral cavity (Kent & Read, 1992; Stevens, 1998). Thus, a high F2 is associated with the front-back dimension in articulation. The sounds /i:/ and /i:/ are front vowels and /a:/, /a/, /u:/, and /u/ are back vowels (Kristoffersen, 2000). Consistent with the findings for Norwegian mothers (Englund & Behne, 2005), our study found that back vowels were more front articulated in CDS compared with ADS. Englund and Behne (2005) indicated that speech consists of sensory cues other than auditory ones, such as vision, and argued that vowel fronting in CDS might make articulation more visibly clear to an infant compared to vowels in ADS. They further pointed to methodological choices as an explanation for discrepancies in the literature. Englund and Behne (2005) found that mothers interacted with their children face-to-face when changing diapers, while Kuhl et al. (1997) used a method similar to the one in the present study with specific toys. Intuitively, it is more likely that a child's attention is drawn to a mother's face in the first situation, making visual aspects of CDS more relevant to enhance compared to the second situation. The findings of this study indicate that methodological choices may not have caused the differences in enhancement of visual attributes in CDS; rather, it may have been due to language and/or culturally specific variances in CDS.

Contradictory to our predictions, F3 appeared to be higher for all vowels in CDS compared with ADS, and significantly for /a:/. F3 is both associated with degree of lip protrusion and placement of the tip of the tongue in the oral cavity (Sundberg, 1977). Thus, there is a connection between F2 and F3. If the tongue body is placed at the front, the tip is likely much ahead. Due to the inverse relationship between lip protrusion and F3 (Kent & Read, 1992; Stevens, 1998), the findings indicate that compared to ADS, the vowels in CDS in general are articulated with a more compressed lip rounding.

Although the prototypical differences in F1, F2, and F3 are constant across speech types, our findings showed a tendency for corner vowel differences to be less distinct and hypoarticulated in CDS. Based on the hyperarticulation theory, vowel specification in the CDS produced by the female pedagogical employees may have been perceptually challenging for the toddlers. Despite this, Englund (2005) argued that the hypoarticulation found in Norwegian mothers' CDS could be beneficial for a child's language acquisition process if caused by large variability, which is a consistent finding in Norwegian CDS. While low variability in linguistic input may counteract learning by leading to habituation and cause low attention, the opposite would facilitate learning. This further suggests that adaptations in the CDS of pedagogical employees can support the language acquisition of the children they interact with.

Limitations

To obtain further insight into the qualitative characteristics of the linguistic learning environment in Norwegian kindergartens, the method for eliciting CDS and ADS was constructed to promote natural speech by simulating a natural situation in a known environment. Simultaneously, to compare the possible adaptations in the acoustic-phonetic characteristics, noise in the environment had to be reduced to obtain recordings suitable for acoustic analysis, with occurrences of vowels from the same acoustic environment promoted for both speech types. A semi-structured one-to-one play situation with specific toys and a conversation with the experimenter was considered to provide the most pragmatic and natural situation for mapping the possible differences in acoustic-phonetic characteristic of the corner vowels in CDS compared with ADS.

The method also led to an uneven number of occurrences of the same vowel categories in CDS and ADS for each of the participants. On average, eight occurrences for each of the CDS vowels were acoustically analyzed for each participant, compared to an average of three occurrences for each of the ADS vowels. To avoid a large variance ratio, which could weaken the robustness of the statistical analyses (Blanca et al., 2018), the initial data were aggregated to create means for the independent variables, speech type (CDS and ADS) and vowels (/a:/, /a/, /i:/, /i/, /u:/, and /u/), for each of the participants. This produced $N = 33$ for the 12 within-subject factors in the one-way repeated-measures ANOVAs for F0 means, F0 range means, duration, vowel space, and F1–F3. Aggregation leads to reduction of the amount of information that can be drawn from the initial data, meaning that conclusions regarding single observations based on aggregated data cannot be drawn due to ecological fallacy (Steel & Holt, 1996). However, aggregation was regarded as appropriate due to data being compared on a group level in this study.

As is common in linguistic research, most of our data did not meet the assumption of sphericity. To construct more valid critical *F*-values and avoid an increase of the type I error rate, the Greenhouse-Geisser correction was applied due to $\varepsilon < .75$ (Field, 2013).

The findings of the present study display adaptations in some qualitative aspects of the pedagogical employees' speech in interaction with toddlers. Although pedagogical employees interact one-to-one with toddlers during their working day, most of the interactions are with other children. We must consider the possibility that the adaptations in CDS found in the present study may differ from adaptations in other types of interactions. Furthermore, we did not examine the general amount of CDS a toddler is exposed to in the kindergarten. Thus, the findings are limited to the presented experimental situation. Despite these limitations, our study provided an insight into the qualitative linguistic learning environment that female pedagogical employees in Norwegian kindergartens provide, which may affect toddlers' language development.

Conclusions

By investigating the adaptations in the CDS of female Norwegian pedagogical kindergarten employees in interaction with toddlers, this study aimed to shed light on qualitative characteristics of the linguistic learning environment in Norwegian kindergartens. The findings imply that, similarly to Norwegian mothers, female Norwegian pedagogical employees' have a smaller vowel space area and, therefore, hypoarticulate vowels in CDS compared with ADS. This, along with the use of higher vowel mean pitch and greater variation in vowel pitch range in CDS than in ADS, indicates that in a play situation with a toddler, pedagogical employees mainly enhanced affective aspects in their speech. These aspects have been shown to aid language learning in previous studies on the effects of CDS. This suggests that adaptations in the CDS of female pedagogical employees may be helpful for the language acquisition processes of toddlers in Norwegian kindergartens.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

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