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Phonological patterns in Mandarin–English bilingual children

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Abstract

Adele Miccio recognized the paucity of information on the phonological development of children from diverse linguistic and cultural backgrounds, and emphasized the need to apply advances in bilingual phonological research toward an appropriate phonological measure for bilingual children. In the spirit of her pioneering work, the present study investigated both Mandarin and English phonological patterns in typically-developing 5-year-old bilingual children in an English-immersion programme in Taiwan. Consonant and vowel accuracy, number and types of phonological processes, and Mandarin-influenced English patterns were assessed on a single-word assessment in each language. Results indicated comparable levels of phoneme accuracy and similar rates and types of phonological processes for bilinguals and their monolingual counterparts. A number of English phonological processes for bilinguals, however, suggested a possible Mandarin influence. The present results reiterate Dr Miccio's call for interdisciplinary collaboration to enhance one's understanding of bilingual language development, to advance successful intervention for bilingual children.

Keywords: *Multilingualism, phonological acquisition, Mandarin, English*

Introduction

Research on phonological development has largely focused on the development of monolingual children, particularly monolingual English speakers, with languages other than English, or bilingual children receiving relatively little attention (Goldstein, Fabiano, and Washington, 2005). In recent years, Dr Adele W. Miccio worked to remedy this situation by examining phonological and literacy acquisition in young bilingual speakers of Spanish and English (e.g. Miccio, Hammer, and Toribio, 2002; Hammer, Miccio, and Wagstaff, 2003; Hammer, Lawrence, and Miccio, 2007; 2008). In her 5-year research grant from the National Institute of Child Health and Human Development (NICHD, Miccio, 2005), Dr Miccio noted the paucity of information on phonological development in diverse languages and cultures, and emphasized the importance of applying advances in phonological theory and

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bilingual research to the creation of valid and reliable phonological measures for bilingual children.

Echoing Dr Miccio's view, the recent surge of research on bilingual phonology has added valuable information to our understanding of bilingual linguistic systems (e.g. Holm and Dodd, 1999; Goldstein and Washington, 2001; Paradis, 2001; Yavaş, 2002; Goldstein et al., 2005; Munro, Ball, Müller, Duckworth, and Lyddy, 2005; Bunta, Fabiano-Smith, Goldstein, and Ingram, 2009). Most published studies of bilingual children, however, are either observational case studies of simultaneous bilingual children or those involving sequential bilinguals learning a second language (L2), typically English, in an L2-dominant environment (Dodd, So, and Li, 1996; Goldstein and Washington, 2001; Anderson, 2004; Munro et al., 2005; Gildersleeve-Neumann, Peña, Davis, and Kester, 2009). In addition, most bilingual phonology literature focuses on children acquiring two Indo-European languages, such as French–English or Spanish–English (Law and So, 2006). It is crucial to further study the phonological patterns of bilinguals acquiring different language pairs in different contexts (Holm and Dodd, 1999; Goldstein and Kohnert, 2005). For example, in many Asian countries, English is the priority foreign language choice for children in schools (Nunan, 2003). It has been estimated that more than 60% of pre-school children in Taiwan study English before entering elementary school: 48% of them before the age of 3 years (Huang, 2002; Liang, 2002). Parents and early childhood professionals have voiced concern about the possible impact (e.g. accented speech) that early English exposure might have on children's development of their first language (L1). To date, little is known about whether the phonological patterns of bilingual children learning English as a second (ESL) or foreign language (EFL) in a non-English-speaking community resemble the patterns of bilingual children in an English-speaking one. In the spirit of Dr Miccio's contribution to bilingual research, the present study sought to extend our knowledge of bilingual phonological development to yet another bilingual group—young bilingual speakers of Mandarin Chinese and English—by examining phonological patterns of typically-developing 5-year-olds attending an English-immersion programme in Taiwan.

Mandarin and English phonology

We begin with a brief comparison of Mandarin Chinese and English phonology. A more comprehensive discussion of Mandarin phonology can be found in Hua (2002) and Norman (1988). Mandarin, a Sino-Tibetan language, is the most widely used Chinese dialect and the official language of China and Taiwan. Mandarin syllable structure is $(C_{0-1})V(C_{0-1})$ and, therefore, relatively simple compared with English. While onsets and codas are optional, the vowel in the nucleus is compulsory in Mandarin. Unlike English, Mandarin prohibits consonant clusters. Mandarin has a total of 22 consonants, with 21 (except /ŋ/) allowed in the initial position and only /n/ and /ŋ/ in the final position. While voicing is a distinctive feature in English, Mandarin makes a distinction between aspirated and unaspirated consonants (Norman, 1988; Ladefoged and Maddieson, 1996). There are six pairs of consonants with this distinction: all of them voiceless. Mandarin and English share nine consonants /p, t, k, m, n, ŋ, f, s, l/, though Mandarin has three fricatives /ʂ, ɕ, x/, six affricates /ts, tsʰ, tʂ, tʂʰ, tɕ, tɕʰ/ and one retroflex approximant /ɻ̩/ without English equivalents. In addition to five voiced consonants /b, d, g, v, z/, English interdental fricatives /θ, ð/, post-alveolar fricatives /ʃ, ʒ/ and affricates /ʧ, ʤ/ do not occur in Mandarin.

Mandarin and English vowel systems differ in complexity and structure. Mandarin has six simple vowels, /i, e, y, u, o, a/, although different linguists have proposed systems, ranging from three-to-12 monophthongs (Li and Thompson, 1981; Flege, Bohn, and Jang, 1997; Hua and Dodd, 2000). American English, on the other hand, consists of 12 distinct monophthongs and three phonemic diphthongs (Peterson and Barney, 1951). Mandarin has more complex vowels than English, with nine diphthongs and four triphthongs. Unlike English, Mandarin is a tone language, with four contrastive tones: high level, high rising, falling-rising, and high falling. Appendix A presents a comparison of Mandarin and English phonology.

Phonological development in monolingual English and Mandarin children

Similar patterns of sound development have been identified in studies of phonemic acquisition in English- and Mandarin-speaking children. A recent cross-sectional study by Dodd, Holm, Hua, and Crosbie (2003) indicated that nasals /m, n/, stops /p, b, d/, and the glide /w/ were the most common manners to emerge and stabilize in the phonology of British children's first words. Inter-dental fricatives /θ, ð/, the affricate /ʤ/, and liquids /l, r/ emerged and stabilized later. Similar findings on sound class development of Mandarin-speaking children were reported in another cross-sectional study of 129 Mandarin-speaking children between the ages of 1;6–4;6 in Beijing, China by Hua and Dodd (2000). In this study, all 21 syllable-initial consonants of Mandarin emerged in all the children's phonetic inventories by the age of 4;6. All stops (alveolar, velar, and initial nasals) and two fricatives (palatal and velar) were acquired first, whereas two affricates (alveolar /ʦ/ and /ʦʰ/) and an approximant (retroflex /ɹ̣/) were acquired last. These findings resemble the observations of other small-scale or diary studies of the phonological development of Chinese-speaking children (see the review by Lee, 1996).

Nonetheless, studies of English- and Mandarin-speaking children reveal some language-specific aspects of phonological development. For example, Hua and Dodd (2000) reported that, unlike English, velar stops in Chinese emerged in children's phonetic inventories about the same time as labial stops, but /k/, /kʰ/, and one velar fricative, /x/, were stabilized earlier than several front consonants. In addition, in many languages, vowels emerge and are mastered much earlier than consonants. Because of the complex diphthongs and triphthongs in Mandarin, however, vowel errors were still found in the diphthong and triphthong productions of the oldest children in Hua and Dodd's study.

With respect to phonological processes, studies of English- and Mandarin-speaking children show, some similarities (e.g. stopping, fronting, backing, and gliding), suggesting universal tendencies. Nonetheless, certain phonological processes appear to be language-specific. For example, Hodson and Paden (1991) suggested that pre-vocalic singleton omissions and backing are quite uncommon in English and highly correlated with reduced intelligibility. These two processes, however, were still evident in the speech of 4-year-old Mandarin-speaking children with typical language development in Hua and Dodd's (2000) study. Similarly, So and Dodd (1995) found that Cantonese children demonstrated a specific phonological process, affrication of /s/, a fairly rare occurrence for English (cf. Smit, 1993). A more typical developmental error for English-speaking children up to age 3;0 would be stopping of /s/.

Mandarin-speaking children's phonological processes seem to resolve later than English-speaking children's. Hua and Dodd (2000) compared the phonological processes used by more than 10% of Mandarin-speaking children with English, Cantonese, and Italian children, and found that Mandarin-speaking children, even after the age of 4 years, still exhibited nine phonological processes for syllable-initial consonants and three for syllable-final consonants. Children from other language groups, however, appeared to have outgrown all these patterns (e.g. Roberts, Burchinal, and Footo, 1990; Dodd et al., 2003).

Phonological development in bilingual children

Some evidence has indicated that bilingual children exhibit different patterns of production when compared to monolingual children speaking either language. Goldstein and Washington (2001) assessed phonological skills of 12 typically-developing 4-year-old bilinguals on a single-word production task in Spanish and English separately. They found that the bilingual children did exhibit some patterns that differed from those of the monolingual children, but bilingual phonological patterns were more similar than not to monolingual ones. Gildersleeve-Neumann, Kester, Davis, and Peňa (2008) examined single-word speech samples collected from three groups of children (monolingual English, English-dominant bilinguals, and relatively balanced English–Spanish bilinguals). Compared to their monolingual English peers, bilingual children had overall lower intelligibility, more consonant and vowel deviations, and more phonological processes and uncommon error patterns, although these differences decreased over time.

Dodd et al. (1996) examined the phonological patterns of 16 Cantonese–English sequential bilingual pre-schoolers in the UK. The children were 25–51 months old. Compared to monolingual children speaking either language, these bilinguals had some different phonological processes in each of their two languages. For example, initial consonant deletion and backing in the bilingual children's English productions are not common in typical English development. Likewise, in another study of two Cantonese–English bilingual children's phonological development (Holm and Dodd, 1999), unusual error patterns in English, such as aspiration and backing, were evident, suggesting the possible influence of Cantonese phonology. Other phonological patterns of these bilinguals were comparable to those exhibited by monolinguals in either language. Overall, while bilingual children manifest some phonological patterns not typically produced by monolinguals, the majority of their phonological errors are also commonly observed in the speech of monolingual children (Goldstein et al., 2005).

Given that Mandarin has more native speakers than any other language in the world, there is a great need for information on the phonological development of monolingual and bilingual children speaking it as their native language. Thus, the present study examined Mandarin and English phonological patterns in a group of bilingual pre-schoolers learning English in Taiwan. Prior research has often depended on cross-study comparisons to differentiate bilingual from monolingual development. To minimize methodological and analysis differences that arise from such comparisons, the present study included a comparison group of Mandarin monolinguals. Two research questions were asked:

(1) Do Mandarin–English bilingual 5-year-olds differ from their monolingual peers in overall phoneme accuracy (as measured by percentage of consonants correct, PCC, and percentage of vowels correct, PVC)?
(2) In comparison to monolingual peers, do Mandarin–English bilingual 5-year-olds exhibit different phonological processes in single-word production?

Method

Participants

Two pre-school programmes participated in the present study: one, an English immersion pre-school, and the other, a Chinese-language pre-school. Both were located in Taipei, Taiwan. A total of 48 children aged 4 or 5 years were recruited. Twenty-five children ($M =$ 5;0) from the English immersion pre-school had been learning English sequentially, as a foreign language at school, since their 3rd birthday (McLaughlin, 1984). For this group, Mandarin was the ambient language outside of school and was spoken consistently at home and in the community, while English was the primary medium of instruction. Each class had one native-speaking English teacher from an English-speaking country. A comparison group of 23 monolingual Mandarin-speaking children (M = 5;3) was included as well. To control monolingual status, only children who communicated primarily in Mandarin and had minimal exposure to English were recruited. After administration of the Mandarin articulation test, one bilingual girl and four monolingual boys[1] were identified as having suspected atypical phonological development and were therefore excluded from data analysis.

With significance set at $p < .01$, the two resulting groups were comparable in terms of gender distribution ($\chi^2 = .29$, $p = .86$), level of maternal education and occupation ($\chi^2 = 5.22$ and 7.04, $p = .16$ and .07, respectively), and non-verbal intelligence, $t(41) = .01$, $p = .99$. The bilingual children were slightly younger than their monolingual peers by 3 months, $t(41) = -1.94$, $p = .06$, yet they had been in their pre-school programme an average of 6 months longer than the monolinguals, $t(41) = 2.54$, $p = .02$. Neither group difference was significant. Means and standard deviations for participants' background information (i.e. age, nonverbal intelligence, and time in pre-school) are displayed in Table I.

Test materials

A Mandarin articulation test (Hua, 2002) was administered to both groups of children. This 44-item test targeted production of monosyllabic ($n = 14$), bisyllabic (29), and trisyllabic (1) words. The word list targets all tones, syllable-initial and syllable-final consonants, and vowels in Mandarin Chinese at least once. High-quality pictures of the items laminated on A4 white paper were used to elicit the target words.

For English phonological assessment, the 53-item *Goldman-Fristoe Test of Articulation-2* (*GFTA-2*, Goldman and Fristoe, 2000) was given to the bilingual children. The *GFTA-2* contains 27 single-syllable, 23 two-syllable, and three three-syllable words. To assess bilingual children's English stress patterns, an additional eight multisyllabic words were included (see Appendix B). The most striking difference between the Mandarin and English phonological systems is that Mandarin is a tonal and monosyllabic language, whereas English is a stress-timed and multi-syllabic language. Thus, the present study attempted to examine possible cross-linguistic effects on bilingual children's English stress productions by including these multisyllabic items.

Procedures

Mandarin and English phonological assessments were administered to the bilingual children in two different sessions. All assessment sessions were administered by the first author, who

Table I. Means, standard deviations, and significance for differences between bilinguals ($n = 24$) and monolinguals ($n = 19$) on control variables.

Variable	Bilinguals	Monolinguals	t	p
Age in months	60.33 (6.01)	63.63 (4.89)	−1.94	.06
Months in school	20.00 (5.78)	13.32 (11.18)	2.54*	.02
TONI-2	109.46 (12.87)	109.42 (9.75)	.01	.99

Standard deviations are in parentheses. * $p < .05$. TONI-2 = Test of Non-verbal Intelligence Test-2.

had become acquainted with all the children during a 3-month period of observational research in their schools. Children's productions were phonetically transcribed on site by the first author. Sessions also were recorded on a Sony HI-MD Walkman Digital Music Player/Recorder with a Shure WL93 wireless lavaliere microphone. The microphone was placed on the child's clothing, ~5 inches from the child's mouth.

Data analysis

Analyses included overall percentage of consonants correct (PCC, Shriberg and Kwiatkowski, 1982), overall percentage of vowels correct (PVC, Shriberg, 1993), and the number and types of phonological processes for both Mandarin and English. Although PCC and PVC were originally intended for application to samples of connected speech, Dodd et al. (2003) have since applied the measures to children's productions from single-word tests. The number of phonological processes (NPP) for both Mandarin and English was a frequency count of the total number of processes present in the child's speech. For example, an NPP of five could mean that a child had five different types of processes or five occurrences of the same type.

All Mandarin samples were transcribed by the first author, who is a native speaker of Mandarin Chinese from Taiwan. Twenty-five per cent of the Mandarin samples were randomly selected to determine inter-judge agreement. One native Mandarin-speaking graduate student in Taiwan with training and experience in phonetic transcription transcribed the samples. Point-by-point transcription agreement was 97% for all phonemes, 95% for consonants, and 99% for vowels.

English samples were independently transcribed by two native English-speaking undergraduate students who majored in speech-language pathology in the US and had previous coursework in phonetics. For 29% of the English samples, point-by-point agreement was 92% for transcription of all phonemes. In addition, the two English transcribers were asked to mark primary stress in words, which proved a more difficult aspect of transcription. Point-by-point agreement for marking primary stress was 85%, ranging from 71–100% agreement per sample. Phonetic transcription differences were resolved by the first author, who compared the disagreements to her on-site transcription and chose the transcription agreed upon by two of the three judges. In some instances, she replayed the sound segment and made a final judgement.

Results

Means and standard deviations for Mandarin PCC, PVC, and NPP are provided in Table II for both bilingual and monolingual children. For the bilingual children, values are also presented for English. In general, both bilingual and monolingual children had high phoneme accuracy rates in their native language. Likewise, the bilingual children also had high accuracy rates in their second language, even though their average English PCC and PVC were lower than their Mandarin PCC and PVC, and their NPP in English was higher than their Mandarin NPP.

Mandarin phonological skills of bilingual and monolingual children

Phoneme accuracy. Mandarin PCC and PVC for both bilingual and monolingual groups were well above 90%, indicating mastery of the Mandarin sound system as a whole. Results of a

Table II. Descriptive statistics and statistical comparisons for average phoneme accuracy, number of phonological processes, and stress accuracy.

	Bilinguals ($n = 24$)		Monolinguals ($n = 19$)					
Measures	*M*	*SD*	*M*	*SD*	*F*	*df*	*p*	η_p^2
Mandarin								
Percentage of consonants correct (PCC)	97.94	2.82	97.17	3.73	.59	1,41	.45	.01
Percentage of vowels correct (PVC)	98.92	1.48	99.02	1.34	.05	1,41	.83	.00
Number of phonological processes (NPP)	3.38	4.67	4.42	5.77	.43	1,41	.51	.01
English								
Percentage of consonants correct (PCC)	89.68	5.86						
Percentage of vowels correct (PVC)	91.22	4.16						
Number of phonological processes (NPP)	10.26	4.42						
Stress	92.79[a]	9.29						

Blank cells indicate that the monolingual children did not receive English phonological assessment.
[a]Percent correct for primary stress.

MANOVA did not show significant effects of language status on Mandarin PCC, PVC, or NPP, $F(1, 41) = .59$, .05, and .43, $p = .45$, .83, and .51, respectively.

Phonological processes. The mean percentage of occurrence of 10 common Mandarin phonological processes was compared for the two groups. These 10 processes were ones still used by more than 10% of the oldest group of Mandarin-speaking children (ages 4;1–4;6) in Hua's (2002) cross-sectional study in Mainland China. Additional patterns observed for all children in both groups were also noted. Mean percentages of occurrence and standard deviations for Mandarin phonological processes are presented in Table III .

Because of the high consonant accuracy exhibited by both groups of children, the average percentages of occurrence for all the phonological processes were quite low and standard deviations were large, indicating great variability within each group. None of the 10 basic patterns had a frequency of occurrence greater than 2%. Only four of the 10 additional patterns were exhibited with a frequency of occurrence greater than 2% by either group: back round vowel /y/ deviation, deretroflexion, denasalization, and deaffrication. High average percentages of occurrence may have resulted from fewer opportunities to produce the process, especially the first three. For between-group comparisons on these Mandarin phonological processes, only /y/ deviation, deretroflexion, and deaffrication were considered for between-group statistical comparison via a MANOVA. No significant group differences for these patterns were identified, and the effect sizes were near zero, $F(1,41) = .28$, .45, and .75, $p = .60$, .51, and .39, $\eta_p^2 = .01$, .01, and .02.

English phonological skills of the bilingual children

To examine English phonological productions in the bilingual children, accuracy of consonants and vowels was examined, along with the frequency of various phonological processes.

Phoneme accuracy. Even though most of the bilingual children were reported to have been learning English for only about a year and a half, their average English consonant and vowel accuracy was quite high, with percentages correct of near or greater than 90% (see Table II).

Table III. Percentages of occurrence for phonological processes in Mandarin Chinese for bilingual and monolingual groups.

10 Basic Mandarin phonological processes

	Initial Consonant Deletion 68[a]	Fronting IC 28	Backing IC 29	Stopping 55	Deaspirattion 12	x-Verlarization 43	Final Consonant Deletion 25	/n/ →/ŋ/ 12	Diphthong Reduction 25	Triphthong Reduction 7
Bilinguals	.06 (.30)	.45 (2.19)	.00 (.00)	.53 (1.90)	.69 (3.40)	.00 (.00)	.17 (.82)	.69 (2.35)	1.67 (3.71)	1.19 (4.04)
Monolinguals	.00 (.00)	.38 (1.13)	.00 (.00)	1.34 (2.70)	.44 (1.91)	.12 (.53)	.00 (.00)	.88 (3.82)	1.26 (2.33)	.75 (3.28)

Additional Mandarin phonological processes

	y-deviation 6	Deretroflexion 11	Deaffrication 24	Affrication 44	Stridency Deletion 45	Aspiration 56	Palatalization 47	Assimilation 58	Liquidization 65	Denasalization 5
Bilinguals	14.58 (20.45)	9.30 (12.62)	.87 (4.25)	.38 (1.09)	.56 (2.29)	.00 (.00)	.18 (.60)	.22 (.77)	.06 (.31)	2.86 (7.56)
Monolinguals	11.40 (18.47)	6.88 (10.50)	2.19 (5.79)	.36 (1.14)	1.52 (3.32)	.09 (.41)	.56 (2.44)	.18 (.54)	.24 (.58)	2.11 (6.31)

Standard deviations are in parentheses. IC = Initial Consonant.

[a] Number under each phonological process indicates the number of opportunities to produce it.

Overall, high English phoneme accuracy of the bilingual children suggests the near stabilization of their English phonological system, at least in common, single words. Nevertheless, PCC and PVC were significantly higher in Mandarin (97.94 and 98.92) than in English ($M = 89.68$ and 91.22) and NPP significantly lower ($M = 3.38$ in Mandarin, 10.26 in English), $t(22) = 6.31$, 8.37, and -5.93 ($p < .01$).

Phonological processes. Table IV is a summary of percentages of occurrence and standard deviations for 10 basic phonological processes and additional ones exhibited by the 5-year-old bilinguals. Across the 10 basic processes for consonants, none was exhibited with a frequency of occurrence greater than 10%. Four patterns had a frequency of occurrence greater than 2%: final consonant deletion (FCD, 9.95%), final consonant devoicing (FCDV, 7.27%), syllable reduction (SR, 4.45%), and stopping of fricatives and affricates (ST, 3.00%). Two patterns were not exhibited by any of the children: palatal fronting and deaffrication. Furthermore, the bilingual children only produced two out of 25 additional phonological processes with an average frequency of occurrence greater than 2%: stridency addition (StrA, 2.36%), and stridency deletion (StrD, 6.64%).

Analysis of the children's vowel productions, on the other hand, indicated that the bilingual children exhibited an average of nine vowel errors. Three general vowel substitution patterns are listed in Table V. First, front high lax vowels were substituted by front high tense vowels or by front central vowels (4.66%), for example, /ɪ/ → [i] as in *(e)leven*, or /ɪ/ → [e or ɛ] as in *rabb(i)t*. Next, /ə/ in unstressed syllables was pronounced as [ɑ] or [o] (25.32%, as in *umbrell(a)* or *t(o)mato*). Finally, /æ/ was often substituted by [e] (15.15%, as in *ban(a)na* and *w(a)gon*).

Mandarin-influenced English phonological patterns

Table V also presents possible Mandarin-influenced phonological patterns in the bilingual children's English single-word productions. It should be noted that it was sometimes hard to determine whether a bilingual child's phonological error pattern was the result of a cross-linguistic phonological influence or his or her still-developing phonological system.

The somewhat higher than expected occurrence of final consonant deletion (9.95%) and syllable reduction (4.45%) (compared to reports in the literature for English monolinguals) may have resulted from the influence of morphological patterns of Mandarin on the production of English. For instance, almost all the children except two omitted at least one, if not all, of the three grammatical morphemes which appeared in the word final or coda position of several target words: plural -s as in *pencils* (FCD and StrD) and -es as in *glasses* (SR and StrD), and present progressive -ing as in *jumping* (SR). Specifically, an item analysis was done for all the words with plural morphemes on the *GFTA-2*. Results indicated that, on average, the bilingual children failed to include 2.82 ($SD = 1.94$) plural morphemes in a total of seven plural words. Moreover, when they did include the plural, the bilingual children also exhibited a specific pattern, final consonant devoicing, on the plural words with a voiced final consonant (FCDV), such as *scissors*, *glasses*, *stars*, and *balloons*.

The three general vowel substitution patterns for unstressed /ɪ/, unstressed /ə/, and /æ/ in English might be attributed to the different vowel system of Mandarin or the monsyllabic nature of its words. Perhaps bilingual children are not familiar with the English pattern of vowel reduction in the unstressed syllables of multisyllabic words.

Finally, as with the vowel pattern analysis, analysis of English stress patterns of the bilingual children provided some preliminary results regarding the possible effect of phonological transfer on Mandarin–English bilinguals' stress production in English. Across 34

Table IV. Percentage of occurrence for phonological processes in English for the bilingual group.

FC Deletion (FCD) 44[a]	Syllable Reduction (ST) 26	Stopping 31	Cluster Simplification 26	Liquid Simplification 31	Velar Fronting 19	Palatal Fronting 9	Deaffrication 6	Initial Voicing 26	FC Devoicing (FCDV) 32
9.95 (4.34)	4.45 (4.18)	3.00 (3.70)	.68 (1.46)	1.86 (3.26)	.23 (1.07)	0 (0)	0 (0)	.73 (1.58)	7.27 (5.78)

Additional English phonological processes

Labialization 44	Medial Devoicing 19	Medial Voicing 6	Stridency Addition (StrA) 51	Stridency Deletion (StrD) 28
1.45 (1.92)	1.14 (2.14)	1.55 (5.00)	2.36 (2.55)	6.64 (5.20)

Standard deviations are in parentheses.
[a] Number under each phonological process indicates the number of opportunities to produce it.

Table V. Patterns of Mandarin-influenced English ($n = 23$).

Patterns	Percentage of occurrence	Example
Consonant patterns		
Final consonant deletion	9.95	/'sɪzɚz/ (scissors) → ['sɪzɚ]
Syllable reduction	4.45	/'wɑʧɪz/ (watches) → ['wɑʧ]
Final consonant devoicing	7.27	/stɑrz/ (stars) → [stɑrs]
Vowel patterns		
/ɪ/ → /i/, /e/, or /ɛ/	4.66	/'ræbɪt/ (rabbit) → ['ræbet]
/ə/ → /ɑ/ or /o/	25.32	/bə'nænə/ (banana) → [bɑ'nɑnɑ]
/æ/ → /e/ or /ɑ/	15.15	/'vækjum/ (vacuum) → ['vekjum]
Stress deviation	7.21	/tə'meto/ (tomato) → ['to'me'to]

multisyllabic words, bilinguals produced primary stress correctly 92.79% of the time (SD = 9.29), with accuracy ranging from 63.24–100%. The two transcribers indicated alterations of both trochaic and iambic stress. Further inspection revealed that trochaic stress deviations often were exhibited on bisyllabic words with an unstressed vowel other than /ə/, such as *window*, *monkey*, *yellow*, *feather*, etc. Another stress deviation pattern was observed on iambic words with a reduced vowel /ə/, when the bilinguals substituted schwa with another vowel, such as in *banana* /bə'nænə/ → ['ba'na'na], *tomato* /tə'meto/ → ['to'me'to], etc. Both patterns sounded as if bilinguals were assigning equal stress to each syllable in the multisyllabic word, rather than distinguishing between primary and secondary stress.

Discussion

In accordance with Dr Miccio's advancement of bilingual research, the present study extends our knowledge of phonological development to young bilingual speakers in contexts where the second language is not the ambient one. Overall results showed that the bilingual children did not differ significantly from their monolingual Mandarin-speaking peers in terms of phoneme accuracy and phonological processes in Mandarin, with both groups achieving high consonant and vowel accuracy on single-word productions. Similarly, the bilingual children also achieved high phoneme accuracy for both consonants and vowels in English, suggesting near mastery of their L2 phonology, at least in single words, even in a context where exposure to L2 was limited outside of school. Nonetheless, the bilingual children, while demonstrating high accuracy rates for both English PCC and PVC (although not as high as for Mandarin), exhibited specific Mandarin-influenced phonological patterns in English.

Comparison of monolingual and bilingual groups

The bilingual 5-year-olds in the present study had high accuracy rates for PCC and PVC in Mandarin, belying concerns about the possible effect of early English exposure on children's phonological skills in their native language. In addition, the frequency of occurrence of all Mandarin phonological processes was almost negligible, and comparable for the two groups. Similarly, this group of bilingual children showed high averages for consonant and vowel accuracy in English single-word productions, with percentages correct near or greater than 90%. Except for final consonant deletion, none of the other basic phonological processes occurred 10% or more of the time.

Table VI provides data comparing the English phonological productions and processes of the bilingual children in the current study to English data from typically-developing Spanish–English bilinguals, Cantonese–English bilinguals, and American and British monolingual English-speaking children. Overall, the average PCC for the bilingual children in the present study was similar to the PCC for British monolinguals, but was slightly lower for Spanish–English bilinguals in the US and Cantonese–English bilinguals in the UK (both of the latter with ambient English). The mean PVC for the present bilingual group, however, appears lower than for British monolinguals and Spanish–English bilinguals. Vowels are generally reported as one of the early-mastered aspects of the sound system (Dodd et al., 2003). The bilingual children of the present study generally appeared able to produce English vowels accurately; yet they still exhibited certain substitution patterns. According to Holm (2007), in typical development of Cantonese-influenced English by bilinguals, vowel errors are still evident at age 4 (see also the low PVC in Table VI). These error patterns may reflect the phonological contrasts between the bilinguals' two languages. In the present study, most of the bilingual children's errors were seen on English vowels that do not occur in their native or dominant language. Alternately, some of the vowel errors could be due to unfamiliarity with the vowel reduction pattern in the unstressed syllables of English.

Table VI. Comparison of bilingual and monolingual English speakers on English phonological measures and processes.

	Current study bilinguals ($n = 24$)	Spanish–English[b] bilinguals ($n = 12$)	Cantonese–English[c] bilinguals ($n = 16$)	American monolinguals[d] ($n = 145$)	British monolinguals[e] ($n = 291$)
Country	Taiwan	US	UK	US	UK
Mean age (age range)	5;0	4;7	(2;1–4;8)	5;0	4;8
Phoneme accuracy					
Percentage of consonants correct (PCC)	89.7	94.1	94.8	—	90.4
Percent of vowels correct (PVC)	91.2`	98.3	73.9	—	98.90
Phonological processes					—
FC Deletion	10.0	4.2	8/16[f]	2.4	
Syllable Reduction	4.5	.0	3/16	.5	5.0[g]
FC Devoicing	7.3	2.1	3/16	—	.0[h]
Stridency Deletion	2.4	—[a]	—	—	—
Stopping	3.0	6.9	1/16	.8	3.0
Cluster Reduction	.7	3.2	12/16	9.7	8.0
Liquid Simplification	1.9	1.3	3/16	4.5	23.0[i]
Fronting	.2	1.4	4/16	1.6	13.0

FC = Final Consonant. Unless otherwise noted, values for 'Phonological Processes' are percentage of occurrence. [a] Not reported. [b] Goldstein and Washington (2001); [c] Dodd et al. (1996); [d] Roberts et al. (1990); [e] Dodd et al. (2003); [f] Numbers indicate number of children out of a total of 16 participants evidencing the error pattern; [g] Data were originally reported as mean use of the error patterns (i.e. proportions), but for the sake of comparison have been converted to percentages; [h] Originally reported as 'Voicing Errors'; [i] Originally reported as 'Gliding'.

Furthermore, the average PCC and PVC for the bilingual children's first language (i.e. Cantonese) in the Dodd et al. (2003) study were 90.13% and 91.86%, respectively, which were lower than the L1 PCC and PVC for the present bilingual group. Dodd et al. suggested that young Cantonese–English bilinguals have delayed phonological development and atypical phonological processes in both their L1 and L2. As suggested by the authors, the delay might be attributable to the still emerging languages of these young children, and the unusual L1 speech patterns might result from an English-dominant language environment. The bilingual children in the present study were much older (with a mean age of 5;0) than those in the Dodd et al. study (from 2;1 to 4;8). It is not surprising, then, that the former had higher consonant and vowel accuracy as well as fewer phonological processes in their L1. In addition to the age difference, the bilingual children in the present study clearly had more exposure to their L1, which was their ambient language. The context and amount of L1 exposure may help to prevent unusual speech patterns from occurring in the Mandarin of these bilinguals.

With respect to English, the percentages of occurrence for several basic phonological processes of the bilinguals in the present study were similar to those reported for the Spanish–English bilinguals and American and British monolingual children. These groups of children exhibited comparable percentages of occurrence for three of eight phonological processes (i.e. stopping, liquid simplification, and fronting). Other phonological processes, such as syllable reduction, final consonant deletion, and consonant devoicing, showed a larger discrepancy. Two possibilities may account for the differences. First, the discrepancy may have resulted from the number of opportunities for these phonological processes. For example, the number of multisyllabic words assessed for the syllable reduction process varied in the four studies, from one (Goldstein and Washington, 2001) to 23 (Dodd et al., 2003) or 34 (in the present study). Another explanation for greater frequency of these phonological processes might be the specific influence of Mandarin on English phonology, as discussed later.

To conclude, the bilingual 5-year-olds in the present study, when compared with the monolingual or other bilingual groups, did not show delayed development of their Mandarin and English phonological systems. Neither did they exhibit distinctive phonological patterns in their Mandarin phonological productions, although some of their English phonological patterns had a possible Mandarin influence. The results of the present study were comparable to those reported by Goldstein et al. (2005) for Spanish–English bilingual children. In discussing their failure to find group differences, in contrast to other Spanish–English bilingual studies (e.g. Goldstein and Washington, 2001; Gildersleeve-Neumann et al., 2008), the authors suggested that as bilingual children mature and their two sound systems nearly stabilize, their phonological skills come to resemble those of monolinguals.

Possible Mandarin-influenced English phonological patterns

Several of the bilingual children's consonant and vowel error patterns were somewhat more evident than for English monolinguals, as shown in Table V. As previously suggested, these phonological patterns may be attributable to the different linguistic systems of the bilinguals' two languages. Most of the bilinguals' consonant errors (i.e. FCD, SR, FCDV, and StrD) occurred in the word-final or syllable-coda positions. Mandarin is known for its lack of morphological complexity (i.e. inflectional morphemes) (Li and Thompson, 1981). For example, Mandarin does not have markers for plurals or verb tense. The concept of plurality is expressed by a separate word, such as 'yi4-xie1' [some] or 'xu3-duo1' [many]. Tense is also indicated by additional words or phrases, if required. Therefore, many bilingual children, when taking the English articulation test, did not include obligatory grammatical morphemes for several target words, such as plural -s or -es and present progressive -ing. Failure to include these grammatical morphemes contributed to the high percentages of occurrence for final consonant deletion and syllable reduction.

Similarly, the pattern of final consonant devoicing of the bilinguals may be due to the phonotactic constraints in Mandarin. In comparison to English, Mandarin is far more restrictive in the range of word-final consonants. The simplifications of English coda consonants by Mandarin learners of English have been investigated in several studies (see the review by Broselow, Chen, and Wang, 1998). Broselow et al. (1998) specifically examined the simplification of English syllable codas by adult native speakers of Mandarin in Taiwan. Analysis showed that the participants adopted three types of simplification strategies, namely epenthesis, deletion, and devoicing, to transform the English syllable coda types into structures that conform to typical Mandarin types, with a less marked phonological structure. Goldstein et al. (2005) and Gildersleeve-Neumann et al. (2008) also found more final consonant deletion in the English than Spanish productions of Spanish–English bilinguals. In Spanish, as in Mandarin, few consonants are permitted in the syllable-final position, and many words end in open syllables.

The influence of Mandarin on English vowel productions was also observed in the three general vowel substitution patterns for /ɪ, ə, æ/. Mandarin has fewer monothongs than English. In particular, Mandarin does not have six American English vowels: /ɪ, ɛ, æ, ʌ, ʊ, ɔ/. It appears that the bilingual children had specific substitution patterns for some of these unfamiliar vowels. These substitutions are supported by Chen, Robb, Gilbert, and Lerman's (2001) finding that adult Mandarin speakers were less acoustically comparable to American speakers in the production of unfamiliar English vowels.

Preliminary analysis of the Mandarin–English bilingual children's stress patterns showed a possible effect of phonological transfer. An undifferentiated stress pattern was noted in the bilingual children's productions of bi- and multi-syllabic words. A few bilingual children seemed to assign equal stress to syllables in trochaic words with an unstressed vowel other than /ə/ (e.g. *window*) or in iambic words, where they replaced a schwa with another vowel. These patterns may reflect Mandarin-influenced English, adult pronunciation in Taiwan. Zhang, Nissen, and Francis (2008) found that when Mandarin adults speak English, their less native-like stress patterns may be due to a higher F0 on stressed syllables and a lack of English-like vowel reduction in certain unstressed syllables, suggesting transfer of the Mandarin tonal system to English words. The present findings are consistent with the suggestions by Chen et al. (2001) that Mandarin speakers' vowel errors and stress deviations when they speak English are associated with the joint effect of native-language phonological experience and similarities or differences in the phonological systems of the L1 and L2.

Conclusion

In summary, the Mandarin–English bilingual 5-year-olds did not differ from their monolingual peers in phoneme accuracy in Mandarin and have achieved overall phonological competence on single-word production in both Mandarin and English, in a context where English is not the ambient language. Likewise, the phonological patterns of the bilingual and monolingual children were more similar than different. A few Mandarin-influenced English phonological patterns were suggested, and possible effects of Mandarin-specific phonological properties were discussed. The implications of the present study, in concurrence with those of Dr Miccio and other previous studies, are that speech-language pathologists, when working with English language learners, should be aware of language-specific phonological processes typical in bilingual development and work toward better diagnostic protocols which can clearly distinguish disorder from phonological variation. Furthermore, because of the high rates of phonological accuracy in single words spoken by 5-year-old Mandarin–English bilinguals—even in their L2 English—speech-language pathologists should still consider the possibility of phonological disorder when rates are lower.

The present study is limited in several respects that should be addressed in the future. The high PCC and PVC of the 5-year-old children in the present study suggest that their phonological systems have been acquired and stabilized. Future studies with younger bilinguals might better reveal a trajectory in bilingual phonological development. In addition, other phonological measures, which specifically target possible Mandarin-influenced English patterns (e.g. final consonant deletion, syllable reduction, vowel substitution patterns, and stress deviation, etc.) or potential English-influenced Mandarin patterns (e.g. deaspiration, tonal deviation, etc.) are needed to provide a more complete understanding of bilingual phonological development. Some of these patterns may require acoustic analysis to accurately determine the possible effect of language-specific differences.

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Note

1. Mandarin PCC of these five children ranged from 68.8–82.8, and the phonological processes with percentages of occurrence greater than 10% exhibited by these children are considered atypical for their given ages in Mandarin phonological development. These phonological processes included backing, stopping, deaffrication, and affrication.

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Appendix A

Comparison of Mandarin and English phonology

	Mandarin	English
Tones	4 tones: high level, high rising, falling rising, high falling	None
Syllable structure	($C_{0\text{-}1}$) V ($C_{0\text{-}1}$)	($C_{0–3}$) V ($C_{0–4}$)
Syllable initial consonants	p, p^h, t, t^h, k, k^h m, n f, s, ʂ, ɕ, x l, ɹ ts, ts^h, tʂ, tʂ^h, tɕ, tɕ^h	p, b, t, d, k, g m, n θ, ð, f, v, s, z, ʃ, ʒ, h w, j l, r ʧ, ʤ
Syllable final consonants	n, ŋ	m, n, ŋ p, b, t, d, k, g θ, ð, f, v, s, z, ʃ, ʒ l, r, tʃ, ʤ
Vowels	i, e, y, u, o, a ae, ei, ao, ou, ia, ie, ua, uo, ye iɑo, iou, uae, uei	i, ɪ, e, ɛ, æ, ʌ, ɜ, u, ʊ, o, ɔ, ɑ aɪ, ɔɪ, aʊ

Note. Adapted from Hua (2002), p. 44.

Appendix B

Assessment of English phonological skills: Multisyllabic words

(1) elephant ['ɛləfənt]
(2) octopus ['ɑktəpəs]
(3) kangaroo ['kæŋgəru]
(4) umbrella [ʌm'brɛlə]
(5) tomato [tə'meto]
(6) spaghetti [spə'gɛɾi]
(7) helicopter ['hɛlɪkɑptɚ]
(8) eleven [ɪ'lɛvn̩]