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Original Article

Effects of English-Language Learning Experience on Speech Sound Development Among Preschool Children in Taiwan

Yu-Chun Chih[1,2], Tsai-Ni Han[1], Kou-You Huang[1,2*]

[1] *Department of Speech Language Pathology and Audiology, Chung Shan Medical University, Taichung, Taiwan*

[2] *Language Therapy Room, Chung Shan Medical University Hospital, Taichung, Taiwan*

The aim of this study was to investigate the influence of language learning experience on the development of children's speech sounds. Participants were 40 4-year-old and 40 6-year-old preschool children. They were divided into groups based on their age and English-language learning experience and were given 3 tasks to examine their speech production, speech perception, and phonological awareness. The first task targeted the articulation of Mandarin and English. Stimuli included disyllabic Mandarin words and pseudowords and monosyllabic English words and pseudowords. The results showed that the 6-year-old group performed better than the 4-year-old group. There were no differences between the groups with different language-learning experiences. Moreover, there was no association between language learning experience and age. The second task focused on speech discrimination. Participants were asked to discern the differences between the word-initial phonemes of disyllabic words. Results revealed that the 6-year-old group performed better than the 4-year-old group and the group with more English-language learning experience performed better than the group with less English-language learning experience. However, this pattern was found only among the 4-year-old subjects. The third task tested phonological awareness by deletion of sounds and blending of sounds. The results showed that on the deletion of sounds test, the 6-year-old group performed better than the 4-year-old group and the group with more English-language learning experience performed better than the group with less English-language learning experience. Again, such advantage was found only among the 4-year-old children. On the blending of sounds test, the 6-year-old group outperformed the 4-year-old group and no differences were found between the group with more English-language learning experience and the group with less English-language learning experience. In sum, the results of the current study indicated that exposure to a foreign language does not interfere with the development of speech sounds in the native language. Instead, such experience can expand speech sound development of children and foster their ability to discriminate speech sounds.

Keywords: Language learning experience, Speech development, Speech production, Speech perception, Phonological awareness

Introduction

In Taiwan, some children are learning English at a very young age to meet the needs of international communication and to prepare for English proficiency tests at all levels of the educational system. What is the effect of learning

* Corresponding Author: Kuo-You Huang, PhD
Department of Speech Language Pathology and Audiology, Chung Shan Medical University, Taichung, No.110, Sec.1, Jianguo N. Rd.,Taichung City 40201,Taiwan.
Tel: +886-4-24730022 ext. 12336
E-mail: kyhuang3317@gmail.com; kyhuang@csmu.edu.tw

English in preschool? Does it expand the inventory of speech sounds in children's memory and improve speech production and perception? Or does it interrupt the development of native speech sounds and delay children's speech development? The aim of this study was to investigate these questions by comparing speech sound development in children with more and less English-language learning experience.

Speech Production

Speech sound development is the basis of language development and an important indicator of speech communication ability in children. Speech sound development includes speech production and speech perception. Speech production or articulation is the configuration of articulators to produce verbal signals. Generally, children start to produce meaningful words at 1 year of age. However, when infants start babbling at 6 months, they are trying to form speech sounds by controlling their articulators through practice. As neuromuscular control is not yet well developed in young children, articulation shows different levels of progress. In general, the ability to form vowel sounds develops earlier than the ability to form consonants. Among the consonants, stops, nasals, and glides tend to be better articulated before fricatives, affricates, and liquids. However, there is a fair amount of individual variation[1, 2].

In Taiwan, to modify the Language Disorder Rating Scale for Children, Lin and Lin[3] conducted a massive investigation of 839 children, ranging from 3 to 6 years old. With 90% level as the standard, they discovered that the Mandarin consonants which 3-year-old children can produce are stops /p/, /pʰ/, /k/, /kʰ/, nasals /m/, /n/, liquid /l/, fricative /x/, and affricates /tɕ/, /tɕʰ/. At 3 ½ years of age, children can also produce the sound /t/. At 4 years /ɕ/ and /ts/ and at about 4 ½ years /tʰ/ and /tsʰ/ are added to the inventory. This is followed by /ʂ/ at 5 years. Then, at 5 ½ years, production of the sounds /f/, /tʂʰ/, /s/ and /ʐ/ reaches acceptable accuracy. Therefore, before 6 years of age, most of the sounds can be produced at more than 90% level, except for the affricate /tʂ/. Vowels, other than /y/, which is not mastered until 3 ½ years, can all be produced at 90% level before the age of 3[3]. Cheung examined consonant articulation in two groups of children. One group consisted of 20 children from 3 to 4 years old and the other consisted of 90 children from 4 to 6 years old. He found that the sounds which can be pronounced with 75% accuracy and above by toddlers between 3 and 4 years old are /p/, /pʰ/, /m/, /n/, /kʰ/ and /x/. The sounds produced with 51% to 75% accuracy are /t/, /tʰ/, /k/, /f/, /s/, /tʂ/ and /ts/. The sounds produced with 50% accuracy and below are /ʐ/, /ʂ/ and /tsʰ/[4]. As to the children between 4 and 6 years old, they produced every sound with more than 75% accuracy. If 90% was set as the standard of passing, children 4 years of age failed to produce the sounds /ʂ/, /ʐ/ and /tʂʰ/ and children 6 years of age only failed to produce the sound /ʐ/[5]. From these results, articulation tends to improve as children become older and the ability to produce the sounds /ʂ/, /ʐ/, /tʂʰ/ and /tʂ/ develops later in Mandarin.

Speech Perception

In terms of verbal communication, accessing words from speech signals is a necessary process for restoring meaning. Therefore, the ability to distinguish speech sounds influences the word retrieval process. For example, in Mandarin, the words /pai–tɕʰiəu/ (white ball) and /pʰai–tɕʰiəu/ (volleyball) only differ in the aspiration of the word-initial consonant. However, these two words have different meaning. Therefore, speech sound perception can be a basic index of toddlers' communication ability. There are two theories that explain speech perception: the auditory theory of speech perception and the motor theory of speech perception. The auditory theory states that during the process of hearing, acoustic cues are captured. Listeners associate these cues with certain speech sounds. The whole process relies on the auditory system and does not involve the articulation mechanism[6-8]. Based on the motor theory, speech perception is strongly related to articulatory gestures. Listeners must know the variation in articulatory gestures to clearly perceive different speech sounds[9-12].

Among all factors influencing the speech

perception performance in children, age is the one that has been examined most frequently. In general, research related to speech perception development from infancy to school-age in Mandarin supports the age effect, which means that older children perform better than younger children[5, 13-15]. Nevertheless, the developmental variation in speech perception is still unclear. Previous research has shown that school-age children can distinguish stops with different places of articulation (e.g., /p-k/) with higher accuracy, but their abilities to discriminate palatal affricates and fricatives (e.g., /tɕʰ-ɕ/) and perceive retroflexes (e.g. /tʂ-ts/, /tʂʰ-tsʰ/, /ʂ-s/) are not as strong as those of adults[14-17].

Aside from the age effect, previous studies have shown that language learning experience is an important factor. For example, Lisker and Abramson [18] used synthesized sounds, manipulating the length of voice onset time to test the categorical perception of participants from various language backgrounds, including Spanish, English and Thai. The results revealed that participants from different language backgrounds have different perceptual boundaries, which means that their boundaries for aspirated and non-aspirated sounds are different[18]. Japanese adults usually have difficulty distinguishing between /l/ and /r/, as these two sounds do not discriminate word meanings in Japanese. However, English speakers can clearly distinguish between them[19]. From these previous studies, language learning experience influences speech perception. That is to say, although the physical dimensions of signals are identical, after being processed perceptually, their mental representation differs.

The effect of language learning experience has been further substantiated by studies on the perception of infants. These studies have pointed to a phenomenon: the development of infants' perceptual discrimination ability follows a universality-to-specificity principle, which means that newborns can differentiate all kinds of sounds. As their language learning experience becomes more homogeneous, infants tend to discriminate sounds in their native language better than those in non-native languages[20-25]. For example, at the second month after birth, the ability of Japanese babies to discriminate between /r/ and /l/ is equal to that of American babies. However, as they grow up in distinct language environments, they start to show different perceptual performances[26]. Kuhl claimed that as infants become more familiar with the characteristics of their native speech sounds, they form L1 prototypes in their memory. These prototypes are used during speech discrimination and perceptual magnet effect occurs for similar sounds belonging to the same prototype, drawing them toward the prototype[23, 25]. In the early phase of development, children may rely on acoustic cues to discriminate among speech sounds. However, as they become more accustomed to their language environment, they may rely on speech sound representations stored in the memory. In the assimilation theory, 4 conditions are proposed for how people discriminate among non-native sounds[27]. The easiest condition is when listeners are presented with two sounds belonging to different speech sound categories in their native language. The most difficult condition is when two sounds fall into the same speech sound category. In the third condition, listeners can still discriminate between two sounds when the sounds belong to the same category but one of them is closer to the prototype than the other. In the last condition, when the two sounds presented cannot be categorized into any speech sound category in the listeners' native language, the listeners consider them non-speech and, thus, cannot distinguish between them.

Phonological Awareness

Phonological awareness is defined as the understanding of the sound structure of oral language. This ability is revealed through tasks such as blending syllables or sounds, segmenting syllables or sounds, deleting syllables or sounds, adding or manipulating sounds, and recognizing rhyming words[28, 29]. Over the last decades, many studies have found that phonological awareness is essential to the development of reading ability. Poor phoneme awareness and other phonological skills are predictors of poor reading and spelling[28-37]. Children with weak phonological awareness have difficulty understanding that words can be broken into individual phonemes or acting on speech sound knowledge. This may lead to reading or learning disabilities, as such children do not know

how to decode new words. Moreover, speech sound decoding problems may lead to further difficulties in reading fluently and comprehending written text [29]. In Taiwan, some studies have shown that children's phonological awareness of Mandarin strongly pertains to their reading ability in that language. Children with better phonological skills show better performance on Chinese vocabulary comprehension and reading tests[15, 38, 39].

The aim of this study was to investigate the effects of language learning experience on speech sound development in children. Participants were English-language learning 4-year-old and 6-year-old preschool students whose native language is Mandarin. Their performances on speech production, discrimination, and phonological awareness tasks were compared to investigate whether children with more English-language learning experience perform differently from children with less English-language learning experience. The appropriateness of speech perception theory was also assessed.

Methods

Participants

Participants were recruited from four private preschools in Taichung City. Children received English courses in which Taiwanese teachers and foreign teachers worked in cooperation. However, the amount of time given to English-language learning was not equivalent (English-dominant classes vs. Chinese-dominant classes). The participants were divided into 4-year-old (3y10m-4y2m) and 6-year-old (5y10m-6y2m) groups. After receiving informed consent forms from their parents, the children were given the Test of TONI Nonverbal Intelligence, the Peabody Picture Vocabulary Test-Revised (PPVTR) and a self-edited simple English-language proficiency test. Eighty children were selected after screening 112 children.

Materials and Measures

1. Test of Nonverbal Intelligence (TONI-3): This test was modified by Wu, Tsai, Hu, Wong, Lin and Kuo[40]. Abstract black-and-white pictures were used to evaluate problem-solving abilities. The influences of language, culture and motor ability were excluded. TONI was used to screen for nonverbal intelligence to assess the ability of subjects to participate in the following tasks.
2. Peabody Picture Vocabulary Test-Revised (PPVT-R): PPVT-R was modified by Lu and Liu[41]. This is a valid and effective test for evaluating children's language development and verbal intelligence. It utilizes pictures to assess participants' receptive vocabulary. The purpose of this test was to screen for atypical pattern of development and select those subjects with normal language development to participate in the following tasks.
3. Self-edited simple English-language proficiency test[42]: Question types included picture naming, directive sentences and conversation (Appendix 1). The purpose of this test was to assess the children's English-language proficiency for later grouping. In the first section, there were 20 picture naming questions, containing items such as daily necessities, fruits, animals, transportation modes and domestic appliances. In the second section, 10 simple directive sentences in the form of declaratives were used. The participants were asked to follow commands, for example, "Please close your eyes." In the conversation section, 10 questions and daily greetings were excerpted from the children's English-language textbooks, for example, "How old are you?" The directive sentences and questions were recorded on CD by an English teacher, which was played during the test.

Screening Process

1. After informed consent was obtained from the parents, TONI and PPVT-R tests were administered to the children to evaluate whether their intelligence matched the norm.
2. The sequence of tasks on the simple English-language proficiency test was picture-naming, directive sentences and interrogative sentences. Twenty pictures were presented sequentially followed by the question "What is this?" Each child was required to name the items in the pictures in English. Later, pre-recorded directive

Appendix 1: Self-edited simple English proficiency test

1. Picture-naming

apple	dog	hat	spoon
bicycle	elephant	monkey	train
banana	foot	pencil	telephone
car	horse	pencil	watermelon
clock	hand	shoe	watch

2. Directive sentences

Please stand up.	Please open your mouth.
Please sit down.	Please shake your body.
Please raise your hand.	Please show me your fingers.
Please turn around.	Please take off your shoes.
Please close your eyes.	Please pick up the pen on the table.

3. Conversation

1	How are you?
2	What's your name?
3	How old are you?
4	What day is today?
5	How is the weather today?
6	What color do you like?
7	What kind of fruit do you like?
8	What time do you go to bed?
9	How do you go to school?
10	What is the biggest animal you have ever seen?

sentences and conversations were played using a CD. Each question was played twice and the child's response was recorded as correct or incorrect. If the child did not respond to the question, the question was repeated verbally. If no response was observed again, the child was considered to have answered the question incorrectly. According to this procedure, children with an accuracy rate of 75% and above were assigned to the "more-English-language learning experience group". This group consisted of 40 participants, 20 of whom were 4-year-olds and 20 of whom were 6-year-olds. The genders were balanced in this group. Children with an accuracy rate below 75% were assigned to the "less-English-language learning experience group". This group also consisted of 20 4-year-old and 20 6-year-old children and was gender-balanced. The children were assigned to these groups based on their English-language learning experience and current level of English-language proficiency. This did not mean that those in the "more-English-language learning experience group" had reached a level of English-language fluency..

Task One: Articulation Test

1. Test materials:

   A total of 42 disyllabic Mandarin words and 48 monosyllabic English words were used. Half were pseudowords and the other half were real words. The word initial consonants contained 23 Mandarin consonants and 24 English consonants. The Mandarin pseudowords consisted of two first tone Mandarin syllables with no concrete

Appendix 2: Articulation Test

Mandarin words			Mandarin pseudowords		
paɪ-tʰu (white rabbit)	lan-tɕʰiəu (basketball)	tʂa-tɕi (fried chicken)	pu-tʰa	lu-tɕʰia	tʂu-tɕiɛ
pʰiəŋ-kuɔ (apple)	kuɔ-tɕʰi (national flag)	tʂʰuan-tʂɑŋ (captain)	pʰu-ka	ku-tɕʰia	tʂʰu-tʂa
mu-kua papaya	kʰɤ-lɤ coke	ʂu-tʰiaʊ French fries	mu-ka	kʰu-la	ʂu-tʰa
feɪ-tɕi (airplane)	xan-paʊ (hamburger)	zɻ-koʊ (hot dog)	fu-tɕia	xu-pa	zɻu-ka
tiɛn-xua (telephone)	tɕy-tsʅ (orange)	tsuəi-pa (mouth)	tu-xa	tɕi-tsa	tsu-pan
tʰoʊ-fa (hair)	tɕʰi-ʂweɪ (soda)	tsʰɑʊ-meɪ (strawberry)	tʰu-fa	tɕʰi-ʂa	tsʰu-ma
niəu-naɪ (milk)	ɕi-kua (watermelon)	sən-lin (forest)	nu-na	ɕi-ka	su-la
y-sɑn (umbrella)	əɻ-tuɔ (ear)		yan-sən	əɻ-ta	

English words			English pseudowords		
bus	sheep	gin	/bed/	/ ʃed/	/ dʒed/
dog	think	map	/ded/	/θed/	/med/
god	hand	no	/ged/	/hed/	/ned/
pen	usual	sing	/ped/	/juʒed/	/dɪŋ/
two	view	lead	/ted/	/ved/	/led/
key	that	reach	/ked/	/ ðed/	/red/
fox	zoo	yes	/fed/	/zed/	/jed/
see	chin	wind	/sed/	/tʃed/	/wed/

meaning. The English pseudowords were made up of the consonant under investigation plus vowel to create monosyllabic words (Appendix 2). The intention of using pseudowords was to prevent word familiarity and frequency effect to purely examine children's articulatory ability. The test materials were recorded by a 30-year-old woman who had graduated from an English department and had been teaching English for 8 years. She spoke Mandarin and English fluently. The materials were edited and saved with CSL (Computerized Speech Lab, 4500).

2. Raters:
   The raters were three licensed speech-language pathologists (females between 25 and 30 years old).
3. Test procedure:
   The test was in the form of imitation, which required that the subject repeat what was heard via computer speaker. Three practice items were given before the formal test began. The order of Mandarin and English tests was altered, such that the first participant received the Mandarin test before the English test and the second participant received the English test before the Mandarin test and so on. True words and pseudowords were presented randomly and repeated. The whole process was recorded with the participants facing away from the camera. The articulation test took about 10 minutes to finish. The raters

rated the recordings afterwards based on the initial consonants. For each item, the participants received a point only when at least two of the three raters agreed that the consonant was produced correctly.

Task Two: Discrimination Task

1. Test Materials:
   Twenty pairs of disyllabic meaningless words differing in their initial consonant were used to evaluate speech sound discrimination, for example, /pʰɑn pʰɑn/ and /tʰɑn tʰɑn/.
2. Test Procedure:
   This test was administered in the form of a game called "guess who he is" using two dolls dressed in different colors. The tester explained to each participant that the names of the two dolls would change, but that they would sound alike. The participant had to listen carefully to the names of the dolls. For example, "The doll in red is called /pʰɑn pʰɑn/ and the doll in green is called /tʰɑn tʰɑn/. Can you point out which one is named /pʰɑn pʰɑn/?" Once the child understood the task, he or she was allowed three practice runs before the formal test began. The formal test was conducted with questions played on a computer and heard through a speaker. If the participant could not hear the question clearly, the question was played again. If the participant still could not name the doll correctly, the participant was considered to have failed the question. Each participant took about 10 minutes to finish this task.

Task Three: Phonological Awareness Test

1. Test Materials:
   Deletion of sounds test and blending of sounds test were used to investigate phonological awareness. The selected materials are shown in Appendix 3.
2. Test Procedure:
   Deletion of sounds is the ability to remove the initial consonant from a syllable. The tester explained to each child that they were going to play a game in which sounds were divided into two parts. The tester received one part and the child received the other part. For example, if the target word was /na/, the tester should say /n/ and the child should say/a/. If the target word was /kan/, the tester should say /k/ and the child should say /an/. After three practice runs, 20 formal trials were conducted, and it took about 5 minutes to complete this task. The blending of sounds task investigates the ability to combine sounds. This task consisted of 20 trials. Among them, 10 contained 2 phonemes and 10 contained 3 phonemes. The explanation of the task was given in the form of a game. For example, "When I say /p/ and /an/ you say /pan/." Once the child understood the task, formal trials began. This task was finished in about 5 minutes.

Appendix 3: Phonological Awareness Test

deletion of sounds	blending of sounds
tu	paʊ
tʰən	ku
ka	kʰəŋ
ʂɑŋ	tʂʰa
taʊ	lu
tʂʰaɪ	kɤ
xɤ	pʰən
leɪ	feɪ
fan	tʰaʊ
mi	tʂaʊ
pʰiɛ	xua
tsʰa	tʰiɛn
toʊ	tɕiəŋ

Results

Articulation Task

The results of the articulation task are presented in Table 1. The analysis of variance of Mandarin articulation revealed a main effect of age. The 6-year-old group performed significantly better than the 4-year-old group ($F(1,76)=29.67$, $p<.001$). Effect of language learning experience was not found. That is to say, there were no significant differences between the more English-language learning experience group and the less English-language learning experience group ($F(1,76)=.01$, $p=.94$). There were also no differences between

Table 1. Mean performances on intelligence test, English proficiency test and speech production tasks among groups of different ages and language learning experiences (M-ELE: more English-language learning experience; L-ELE: less English-language learning experience; standard deviation in parentheses).

		Intelligence test		English proficiency test	Mandarin task		English task	
Age	group	TONI	PPVT-R		Words	Pseudo words	words	Pseudo words
6-y-old	M-ELE	114.05	115.95	.95	.98	.93	.95	.92
		(6.13)	(7.40)	(.06)	(.05)	(.11)	(.15)	(.10)
	L-ELE	114.20	115.50	.15	.98	.94	.91	.87
		(5.07)	(6.39)	(.09)	(.06)	(.10)	(.11)	(.11)
4-y-old	M-ELE	111.90	113.30	.80	.95	.82	.87	.82
		(6.42)	(7.57)	(.06)	(.07)	(.13)	(.12)	(.14)
	L-ELE	112.25	112.90	.07	.96	.80	.83	.78
		(5.80)	(5.95)	(.05)	(.08)	(.15)	(.13)	(.16)

boys and girls (F(1,76)=.16, p=.76). A main effect of word type was found with the articulation of words better than that of pseudowords (F(1,76)=42.14, p<.001). There was no interaction between age and language learning experience (F(1,1)=.14, p=.71) or between language learning experience and word type (F(1,1)=.05, p=.82). However, there was an interaction between age and word type (F(1,1)=11.27, p=.001) in the 4-year-old group, but not in the 6-year-old group.

As for the analysis of variance of English articulation, there was a main effect of age with the 6-year-old group performing significantly better than the 4-year-old group (F(1,76)=27.54, p<.001). In addition, a main effect of language learning experience was noted with the group with more English-language learning experience outperforming the group with less English-language learning experience (F(1,76)=6.12, p<.05). Moreover, a main effect of word type was found with better articulation of words than of pseudowords (F(1,76)=7.37, p<.01). No interactions were found between age and language learning experience (F(1,1)=.03, p=.86), between language learning experience and word type (F(1,1)=.03, p=.86), or between age and word type (F(1,1)=.09, p=.76).

Results of further analyses of articulation accuracy in Mandarin and in English are shown in Tables 2 and 3. In Mandarin, the lowest accuracy rate among all children was for the fricative /ʐ/. The average accuracy rate of the 6-year-old group was .73. That of the 4-year-old group was .60. Other sounds that children produced with relatively low accuracy were the retroflex affricates /tʂ/ and /tʂʰ/. The accuracy rates of production in the 4-year-old group and the 6-year-old group were .70 and .83 for /tʂ/ and .78 and .85 for /tʂʰ/, respectively. The production accuracy of /f/ showed significant differences between the two groups., with an average of .78 for the 4-year-old group and an average of .93 for the 6-year-old group. As for sounds in English, the accuracy rates for /θ/, /ʒ/, /v/ and /ʃ/ were lower. This indicated that children have difficulty producing sounds that are absent in Mandarin or that do not have a similar counterpart in their native speech sound memory.

Discrimination Task

The results of the speech discrimination task in Table 4 showed a main effect of age with the 6-year-old group performing better than the 4-year-

Table 2. Mean performances on speech production of Mandarin consonants among groups of different ages and English-language learning experiences.

	6-y-old				4-y-old			
	M-ELE		L-ELE		M-ELE		L-ELE	
	words	Pseudo words	words	Pseudo words	words	Pseudo words	words	pseudo words
p	1.00	1.00	1.00	1.00	1.00	.80	1.00	.90
pʰ	1.00	.90	1.00	1.00	1.00	.70	1.00	.80
m	1.00	1.00	1.00	1.00	1.00	.70	1.00	.80
f	1.00	.80	1.00	.90	.90	.80	.80	.60
t	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
tʰ	1.00	.90	1.00	1.00	1.00	.80	1.00	.70
n	1.00	1.00	1.00	1.00	1.00	.80	1.00	1.00
l	1.00	1.00	1.00	.90	.90	.90	1.00	.80
k	1.00	1.00	1.00	1.00	1.00	.90	1.00	1.00
kʰ	1.00	1.00	1.00	1.00	1.00	.70	1.00	.90
x	1.00	1.00	1.00	.90	1.00	.80	1.00	.80
tɕ	1.00	1.00	1.00	1.00	1.00	.90	1.00	.80
tɕʰ	1.00	1.00	1.00	1.00	1.00	.90	1.00	.80
ɕ	1.00	1.00	1.00	1.00	1.00	.90	1.00	.90
tʂ	.90	.80	.80	.80	.80	.70	.80	.50
tʂʰ	.90	.70	1.00	.80	.80	.80	.80	.70
ʂ	1.00	.80	1.00	.90	.90	.90	.80	.80
ʐ	.80	.70	.80	.60	.80	.40	.80	.40
ts	1.00	.80	1.00	.90	1.00	.80	1.00	.90
tsʰ	1.00	1.00	1.00	1.00	.90	.80	1.00	.80
s	1.00	1.00	1.00	1.00	.90	.90	1.00	.90
y	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.70
əɻ	1.00	1.00	1.00	1.00	.90	.90	1.00	.90
mean	.98	.93	.98	.94	.95	.82	.96	.80
(SD)	(.05)	(.11)	(.07)	(.10)	(.07)	(.13)	(.08)	(.15)

old group ($F(1,76)= 57.92$, $p<.001$) and a main effect of language learning experience with the more English-language learning experience group performing better than the less-English-language learning experience group ($F(1,76)=12.53$, $p=.001$). There was an interaction between language learning experience and age ($F(1,1)=13.82$, $p<.001$). This advantage of English-language learning experience was only found in the 4-year-old group, not in the 6-year-old group. Sound pairs with lower

Table 3. Mean performances on speech production of English consonants among groups of different ages and English-language learning experiences.

	6-y-old				4-y-old			
	M-ELE		L-ELE		M-ELE		L-ELE	
	words	Pseudo words	words	Pseudo words	words	Pseudo words	words	pseudo words
b	1.00	1.00	1.00	1.00	1.00	.90	.90	1.00
d	1.00	.90	1.00	1.00	.90	1.00	1.00	1.00
g	1.00	1.00	1.00	.90	1.00	1.00	.90	1.00
p	1.00	1.00	.80	.80	.80	.70	.70	.70
t	.90	.90	1.00	1.00	1.00	1.00	1.00	.90
k	1.00	1.00	1.00	1.00	1.00	.90	1.00	.80
f	.90	.80	.80	.80	.70	.80	.70	.70
s	1.00	1.00	1.00	1.00	1.00	.90	1.00	1.00
ʃ	1.00	.90	.70	.70	.70	.70	.70	.80
θ	.80	.80	.70	.70	.60	.70	.60	.40
h	1.00	1.00	1.00	.90	1.00	1.00	.80	.80
ʒ	.80	.80	.80	.70	.80	.50	.80	.50
v	.80	.80	.80	.80	.80	.70	.80	.60
ð	1.00	.80	.80	1.00	.80	.80	.80	.70
z	.90	.80	.80	.70	.70	.60	.60	.60
tʃ	1.00	1.00	1.00	.80	.80	.70	.70	.70
dʒ	.90	.80	.80	.80	.80	.80	.80	.70
m	1.00	1.00	1.00	1.00	.90	.80	.80	.80
n	1.00	.80	1.00	.80	1.00	1.00	1.00	.80
ŋ	1.00	1.00	1.00	.90	.90	.90	.90	.90
l	1.00	1.00	1.00	1.00	1.00	.90	1.00	1.00
r	.90	.80	.90	.80	.90	.70	.80	.70
j	1.00	.90	1.00	.80	.90	.80	.80	.80
w	1.00	1.00	1.00	.90	.80	.80	.80	.70
mean	.95	.92	.91	.87	.87	.82	.83	.78
(SD)	(.15)	(.10)	(.11)	(.11)	(.12)	(.14)	(.13)	(.16)

than .05 passage rate among 4-year-old children in the less-English-language learning experience group were: /ʐ/-/l/ (.30), /ʐ/-/n/ (.30), /tʂ/-/ts/ (.40) and /tʂ/-/tʂʰ/ (.40). These results suggested that young children in Taiwan have difficulty discriminating between retroflex and non-retroflex sounds.

Table 4. Mean performances on speech discrimination task related to phonetic contrasts for groups of different ages and English-language learning experiences.

	6-year-old		4-year-old	
Phonetic contrasts	M-ELE	L-ELE	M-ELE	L-ELE
aspiration-unaspiration in stops				
p-p^{h}	1.00	1.00	.70	.70
t-t^{h}	1.00	1.00	1.00	.80
k-k^{h}	1.00	1.00	.90	.60
aspiration-unaspiration in affricates				
ts-ts^{h}	.80	1.00	.80	.50
tʂ-tʂ^{h}	1.00	1.00	.90	.40
tɕ-tɕ^{h}	1.00	1.00	.90	.70
voiced-voiceless in fricatives				
ʂ-ʐ	1.00	.80	.90	.90
different articulate place in stops				
t-k	.80	1.00	.90	.60
ph-t^{h}	1.00	1.00	.90	.70
p-k^{h}	1.00	1.00	.90	.90
different articulate place in fricatives				
j-f	1.00	1.00	.90	.80
ʂ-s	.80	.80	.70	.80
ɕ-ʂ	.80	.80	.70	.70
different articulate place in affricates				
tʂ-ts	1.00	1.00	.90	.40
tʂ^{h}-ts^{h}	1.00	.70	.70	.60
different articulate place in nasal				
m-n	1.00	1.00	.70	.80
fricative-nasal				
ʐ-n	.80	1.00	.60	.30
fricative-lateral				
ʐ-l	1.00	1.00	.90	.30
nasal-lateral				
n-l	1.00	1.00	.90	.70
m-l	1.00	1.00	1.00	.50
mean(SD)	.95(.09)	.96(.10)	.84(.11)	.64(.18)

Table 5. Mean performances on phonological awareness tasks among groups of different ages and English-language learning experiences (standard deviation in parentheses).

	6-year-old		4-year-old	
Tasks	M-ELE	L-ELE	M-ELE	L-ELE
Deletion of sounds test	.88 (.05)	.86 (.04)	.72 (.07)	.61 (.07)
Blending of sounds test	.86 (.06)	.87 (.07)	.14 (.07)	.08 (.08)

Phonological Awareness Task

The results of deletion of sounds test are presented in Table 5. On analysis of variance, there were main effects of age ($F(1,76)=85.56$, $p<.001$) and language learning experience, with the more English-language learning experience group performing better than the less English-language learning experience group ($F(1,76)=11.01$, $p<.01$). An interaction was found between age and language learning experience ($F(1,1)=5.09$, $p<.05$), with English language learning advantage present only in the 4-year-old group. On blending of sounds test, the 6-year-old group performed significantly better than the 4-year-old group ($F(1,76)=115.98$, $p<.001$), with no differences between the English-language learning experience groups ($F(1,1)=1.86$, $p=.181$). The 4-year-old groups could barely finish the blending of sounds test and the passage rate was nearly zero.

Discussion

The aim of this study was to investigate the effects of foreign language learning experience on speech sound development. The first task involved using words and pseudowords in Mandarin and English to examine articulation. The main findings were:

1. In both English and Mandarin, the 6-year-old group outperformed the 4-year-old group.
2. The group with more English-language learning experience performed better in the articulation of English sounds, while the two groups showed no differences in the articulation of Mandarin sounds.
3. There was word effect in English in both the 6-year-old and 4-year-old groups, but that in Mandarin only occurred in the 4-year-old group.

These results showed that age is a determinant of children's articulation performance. The main effect of age was found for both Mandarin and English and for both words and pseudowords, which is in accordance with previous studies[3-5]. There was no difference in Mandarin sound production between the English-language learning experience groups, indicating that English-language learning experience does not affect children's articulation of their native language in Taiwan. The word effect of Mandarin was only found in the 4-year-old group, indicating that word familiarity or frequency effect is more salient in younger children. The group with more English-language learning experience performed better in the articulation of English sounds, revealing the effect of language learning experience. Word effect occurred in English articulation in both the 6-year-old and 4-year-old groups, indicating that children use their word knowledge to guess the sounds they hear. Although the pseudowords obeyed the phonotactic rules of word formation, they do not exist. Young children may not be able to rely on semantic cues from their memory to retrieve phonetic sounds. Therefore, the pseudowords were more difficult for them. There were no differences in Mandarin sound articulation of words and pseudowords among 6-year-old children, suggesting that 6-year-old children are more proficient in articulatory maneuvering of native language sounds and more capable of focusing on the pronunciation of single segmental

elements. For these participants, English was a language that they had just begun learning, so it is reasonable that they cannot control the articulation of English as well as the articulation of their native language. Therefore, there was a gap between the articulation of words and pseudowords in English.

The purpose of this study was to clarify whether the learning of English interferes with the development of native language proficiency. Based on the results of the first task, the group with more English-language learning experience did not fall behind their counterparts with less English-language learning experience in terms of articulation in Mandarin and showed better performance in terms of articulation of English speech sounds that are not analogous to speech sounds in Mandarin, such as /θ/, /ʒ/, /v/ and /ʃ/. According to the assimilation theory proposed by Best, McRoberts & Sithole[27], the results of the current study indicated that English-language learning experience does not affect speech sound production in Mandarin. Instead, such experience expands speech inventory, reinforcing pronunciation of non-native sounds. This inference was also supported by the results of the speech discrimination task.

On speech discrimination task, the 6-year-old group performed better than the 4-year-old group, displaying a significant age effect. The more English-language learning experience group outperformed the less English-language learning experience group, but only among the 4-year-old subjects. Comparing the children's performance in Mandarin sound articulation and in speech discrimination, the accuracy rates of 6-year-olds for production and perception were very close, around .95. The formation of stimuli in the speech discrimination task was analogous to the use of pseudowords. Therefore, the accuracy of pseudowords in the articulation task was used for comparison. Speech discrimination ability of 4-year-olds with more English-language learning experience was similar to Mandarin pseudoword articulation ability (.84 vs. .82). However, in terms of speech discrimination ability of the 4-year-old less-English-language learning experience group, there was lower accuracy of pseudoword articulation in Mandarin (.64 vs. .80). These results suggested that although the 4-year-old more-English-language learning experience group was not as proficient as the 6-year-old group, English-language learning experience improved their speech discrimination sensitivity, supporting the inference that foreign language learning experience expands the phonetic inventory of young children.

The effect of age was still significant in the third task - deletion of sounds and blending of sounds test. The 6-year-old group performed significantly better than the 4-year-old group, regardless of English-language learning experience. There was no difference in performance between the 6-year-old groups. However, the 4-year-old with more English-language learning experience group demonstrated finer control over deletion of sounds than the 4-year-old with less English-language learning experience group. The blending of sounds test was very challenging for the 4-year-old children, especially the CVV and CVVC syllable structures. These results indicated that their phonological awareness is not fully developed and knowledge of phonology is not innate but, rather, learned.

Comparing the results of the present study with the findings of previous research, Lin & Lin[3] found that the Mandarin consonants that 3-year-old children can produce with acceptable accuracy are stops /p/, /pʰ, /k/, /kʰ/, nasals, /m/ and /n/, liquid /l/, fricative /x/, and affricates /tɕ/ and /tɕʰ/. At the age of 3 1/2, /t/ is added to the inventory. Then, /ɕ/ and /ts/ are produced at 4 years of age, followed by /tʰ/ and /tsʰ/at 4 1/2, /ʂ/ at 5, and /f/, /tʂʰ/, /ʐ/and /s/ at 5 1/2. The sound /tʂ/ is the slowest to develop in Mandarin-speaking Taiwanese children, with less than .90 accuracy rate even after the age of 6. Zhang[4] and Zhang & Hsu[5] found that the sounds that had not reached the threshold accuracy rate at 4 years of age are /ʂ/, /ʐ/and /tʂʰ/, with /ʐ/ still below the threshold accuracy rate at 6 years of age. In the present study, the sounds with the lowest accuracy rates were /ʐ/, /tʂʰ/ and /tʂ/. Moreover, the 4-year-old groups could not articulate /f/ well. These results were consistent with the findings of previous studies, suggesting that the pattern of speech development in children in Taiwan has remained similar over the years. Further analysis of articulation comparing retroflex and non-retroflex sounds revealed that children in Taiwan have consistent

Table 6. Mean performances on retroflex and non-retroflex sound test in Mandarin among different age groups.

	retroflex				Non-retroflex		
group	tʂ	tʂ^h	ʂ	ʐ	ts	ts^h	s
6-yr-old	.83	.85	.93	.73	.93	1.0	1.0
4-yr-old	.70	.78	.85	.60	.93	.88	.93

difficulty in producing retroflex sounds (Table 6). Among all retroflex sounds, /ʐ/ replaced /tʂ/ as the hardest-to-produce Mandarin consonant in Taiwan. Whether this is a result of the influence of Taiwanese, a dialect in Taiwan with no retroflex sounds, is worthy of further investigation.

The results of speech discrimination tasks in studies by Zhang[4] and Zhang & Hsu[5] have shown that the accuracy rate of sound pairs /n-l/, /p^h-t/ and /t-k/ is .75, while that of sound pairs /f-x/ and /tʂ-ts/ is only .40. According to the results of the current study, the sound pairs that 4-year-old children in the less English-language learning experience group found difficult to discriminate were /ʐ-l/ (.30), /ʐ-n/ (.30), /tʂ-ts / (.40) and / tʂ-tʂ^h/ (.40). The overall pattern was similar. The sounds which were difficult in terms of production, such as /ʐ/, /tʂ/ and /tʂ^h/, were also more difficult in terms of speech discrimination. Such results support the motor theory of speech perception which states that speech perception is strongly related to production and that a listener must know the differences among articulation gestures to clearly discriminate speech sounds.

Conclusion

To conclude, the results of the current study indicated that learning a foreign language in preschool does not interfere with articulation, discrimination or segmentation abilities of children in their native language. Instead, learning another language can expand speech sound inventory and improve speech discrimination sensitivity. However, readers are reminded that the children in this study did not have a balanced proficiency in these languages, meaning that they were far more proficient in Mandarin than in English. A long-term investigation may be needed to clarify the influence of language learning experience. What is known is that even if children are learning a foreign language, the native language will remain the dominant communication interface. Therefore, learning a foreign language in early childhood does not affect articulation and discrimination in the native language.

References

1. Gleason JB, Ratner N B: The Development of Language. 7th edition. New Jersey: Pearson Education Inc., 2009.
2. Hazan V, Barrett S: The development of phonemic categorization in children aged 6-12. Journal of Phonetics 2000; 28(4): 377-396.
3. Lin PK, Lin HM: Editing the scale of language impairment for preschool children and related factors. Bulletin of Special Education 1994; 10: 259-281.
4. Cheung HT: Three to four-years old children's perception and production of Mandarin consonants. Language and Linguistics 2000; 1(2): 19-38.
5. Cheung HT, Hsu BH: Chinese children's production and perception of consonants: A developmental study. Journal of the Speech-Language-Hearing Association of the Republic of China 2000; 15: 1-10.
6. Fant, G: Auditory patterns of speech. In W. Wathen-Dunn (Ed.), Models for the Perception of Speech and Visual Form (pp.111-125). Cambridge, MA: MIT Press, 1967.
7. Morton J, Broadbent D E: Passive versus active recognition models or is your homunculus really necessary? In W. Wathen-Dunn (Ed.), Models

for the Perception of Speech and Visual Form (pp.103-110). Cambridge, MA: MIT Press, 1967.
8. Stevens KN, Blumstein SE: Invariant cues for place of articulation in stop consonants. Journal of the Acoustical Society of America 1978; 64: 1358–1368.
9. Liberman AM, Cooper FS, Shankweiler DS, Studdert-Kennedy M: Perception of the speech code. Psychological Review1967; 74: 431–461.
10. Liberman AM, Isenberg D, Rakerd B: Duplex perception of cues for stop consonants: Evidence for a phonetic mode. Perception & Psychophysics 1981; 30: 133-143.
11. Liberman AM, Mattingly IG: The motor theory of speech perception revised. Cognition 1985; 21: 1–36.
12. McGurk H, MacDonald JW: Hearing lips and seeing voices. Nature 1976; 264: 746–748.
13. Chen HC: Mandarin auditory speech perception capability of hearing impaired children at ages 3 to 8. Bulletin of Special Education and Rehabilitation 1999; 7: 51-78.
14. Tsao FM, Lee CY, Hsieh YH, Chiu CY: Assessing stop and lexical tone perception in preschool children and relationship with word development. Journal of the Speech-Language-Hearing Association of Taiwan 2009; 24: 39-58.
15. Liu HM, Tsao FM, Chang CJ, Hsu LL: The development of speech discrimination in preschool and school-aged children: association with word comprehension. Bulletin of Educational Psychology 2013; 45(2): 221-240.
16. Jeng JY: The auditory discrimination of Mandarin retroflex contrasts and spectral moment analysis. Chinese Journal of Psychology 2009; 51(2): 157-174.
17. Jeng JY: The auditory identification of Mandarin retroflex features for children with learning disabilities. Bulletin of Special Education 2011; 36(2): 27-50.
18. Lisker L, Abramson AS: (1970). The voicing dimension: Some experiments in comparative phonetics. In Proceedings of the Sixth International Congress of Phonetic Sciences (pp. 563-567). Prague: Academia, 1970.
19. Logan JS, Lively SE, Pisoni DB: Training Japanese listeners to identify English /r/ and /l/: A first report. Journal of the Acoustical Society of America 1991; 89: 74-886.
20. Werker JF, Gilbert JHV, Humphery K,Tees RC: Developmental aspects of cross-language speech perception, Child Development 1981; 52: 349–355.
21. Werker JF, Tees RC: Cross-language speech perception: Evidence for perceptual reorganization during the first year of life. Infant Behavior and Development 1984; 7: 49-63.
22. Werker JF, Fennell CT, Corcoran KM, Stager CL: Infants' ability to learn phonetically similar words: Effects of age and vocabulary size. Infancy 2002; 3: 1-30.
23. Kuhl PK: Human adults and human infants show a "perceptual magnet effect" for the prototypes of speech categories, monkeys do not. Perception & Psychophysics 1991; 50: 93-107.
24. Kuhl PK, Williams KA, Lacerda F, Stevens KN: Linguistic experience alters phonetic perception in infants by 6 months of age. Science 1992; 255: 606–608.
25. Kuhl PK, Iverson P: Linguistics experience and the "perceptual magnet effect". In W. Strange (Ed.), Speech Perception and Linguistic Experience: Issues in Cross-Language Research (pp. 121-154). Baltimore: York Press, 1995.
26. Mehler J, Jusczyk PW, Lambertz G, Halsted N, Bertoncini J, Amiel-Tison C: A precursor of language acquisition in young infants. Cognition 1988; 29: 143-178.
27. Best CT, McRoberts GW, Sithole NM: Examination of perceptual reorganization for nonnative speech contrasts: Zulu click discrimination by English-speaking adults and infants. Journal of Experimental Psychology: Human Perception and Performance 1988; 14: 345-360.
28. Adams MJ: Beginning to read: thinking and learning about print. Cambridge, MA: MIT Press, 1990.
29. Adam NA, Mohammed ME: The impact of raising phonological awareness on improving EFL learners reading comprehension: a case study at preparatory year Najran University. International Journal of English Language Teaching 2017; 5(7): 1-46.

30. Bradley L, Bryant PE: Categorizing sounds and learning to read: a causal connection. Nature 1983; 301: 419-421.
31. Stanovich KE, Cunningham A E, Cramer BB: Assessing phonological awareness in kindergarten children: issues of task comparability. Journal of Experimental Child Psychology 1984; 38(2): 175-190.
32. Tunmer WE, Herriman M, Nesdale AR: Phonemic segmentation skill and beginning reading. Journal of Educational Psychology 1988; 77 (4): 417-27.
33. Yopp HJ: Developing phonemic awareness in young children. The Reading Teacher 1992;45(9): 696-703.
34. Troia G: Phonological awareness intervention research: a critical review of the experimental methodology. Reading Research Quarterly 1999; 34: 28–52.
35. Stahl SA, Murray BA: Defining phonological awareness and its relationship to early reading. Journal of Educational Psychology 1994; 86(2): 221-234.
36. Ehri LC, Nunes SR, Willows DM, Schuster BV, Yaghoub-Zadeh Z, Shanahan T: Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's metaanalysis. Reading Research Quarterly 2001; 36(3): 250–287.
37. Vance M, Rosen S, Coleman M: Assessing speech perception in young children and relationships with language skills. International Journal of Audiology 2009; 48: 708-717.
38. Ko HW, Lee JR: Chinese children phonological awareness ability and later reading ability: a longitudinal study. Journal of National Chung Cheng University 1996; 7(1): 49-66.
39. Huang HS, Chang HR: An analysis of phonemic awareness, word awareness and tone awareness among dyslexic children. Bulletin of Special Education and Rehabilitation 1997; 5: 125-138.
40. Wu WT, Tsai CC, Hu JF, Wong JD, Lin HT, Kuo CC: Test of Nonverbal Intelligence-Third Edition (TONI-3). Taipei, Taiwan: Psychological Publishing Co., Ltd., 2006.
41. Lu L, Liu HH: Peabody Picture Vocabulary Test-Revised. Taipei, Taiwan: Psychological Publishing Co., Ltd., 1994.
42. Jian SR: Development of speech production, speech perception, and phonological awareness in Mandarin-English bilingual children. Unpublished master's thesis, Chaoyang University of Technology, Taichung, Taiwan, 2004.