

五歲前母音空間變化長期分析 Longitudinal Analysis of Developmental Vowel Space before 5 Years of Age

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摘要

本研究報告是母音長期發展歷程第五階段(即48-60個月大)的結果。本階段研究長期追蹤兩位在中文環境中的幼兒,在5歲之前的母音發音變化長期過程。首先將採集的語料以聽覺轉寫記錄,作語音類別及出現頻率分析。再分析各主要母音類型的第一共振峰及第二共振峰的長期變化。這個時期的研究結果顯示:1)延續前一階段觀察結果,男孩的母音F₁及F₂平均值從3歲6個月起開始偏低發展,在5歲前這個階段持續下降,尤其F₂平均值下降更明顯,這和Childers & Wu (1991)發現結果相似。然而女孩的F₁及F₂平均值在這兩個階段並無下降現象,這更確認前一階段發現的性別差異的起始點及發展趨勢;2)單母音中唯一較晚發展的前圓唇音/y/,觀察的個案中女孩較男孩使用稍多,但出現頻率仍偏低;3)女孩較男孩使用較多角落母音/i, u/,尤其在4歲6個月之後;4)母音加鼻音韻尾比前一階段出現頻率有很明顯的增加,男孩女孩在這個時期都有增加使用這類母音的趨勢,但是男孩使用頻率仍低於女孩;5)因為母音加鼻音韻尾這類母音使用頻率增加,使前一階段出現頻率最高的母音類型,雙母音,相對頻率下降許多,但是雙母音使用仍然頻繁,這代表小孩此時對舌頭作靈活準確的控制更熟練。長期的聲學參數資料在目前中外文獻都相當缺乏,長期的聲學分析及語音記錄可提供一個較完整的資料庫,來描述母音發展和生理結構以及聲學參數值的相依性。這樣的研究結果可協助構音障礙臨床診斷及治療計畫。

關鍵字: 母音習得、共振峰頻率、母音空間

Abstract

The present study is the fifth year of a longitudinal observation of the vowel production in Mandarin-learning children. Vowel productions of children aged 48-60 months were audio-taped and analyzed with both perceptual transcription and acoustic measurement. Major findings in the fifth year are: 1) Continuing the trend of decreasing vowel formant values found in the previous stage, there is an obvious decrease in F₁ F₂ values in the boy subject at this stage. The trend is especially evident in F₂ values, which is similar to what was found in Childers & Wu (1991). However, there is no such an obvious change in formant values in the girl subject. This confirms the emergence and the trend of gender difference found in the previous stage at around 3 years and 6 months of age. 2) The girl subject used more high front rounded vowels /y/, which is the only late-acquired single vowel. However, the frequency of occurrence is still relatively low. 3) Corner vowels /i, u/ were used more often by the girl subject. 4) Diphthongs continue to show high frequency of occurrence at this stage. 5) The frequency of vowels with nasal endings shows prominent increase at this stage. There is a steady increase of this vowel category in both genders. However, the girl subject showed more preference in using this vowel category as was found in previous stage. The longitudinal analysis of vowel production provides important references for assessment and treatment of articulation disorders in children.

Keywords: Vowel Development, Vowel Formant Frequencies, Vowel Space

I. INTRODUCTION

This study is designed to investigate the longitudinal developmental process of vocalic production in two Mandarin-learning children from birth to five years old with both perceptual transcription and acoustic analysis. This current study focuses on the development of the fifth year and the continuity in the process.

The acquisition of vowels is less studied than the acquisition of consonants because vowels are generally regarded to be learned earlier than consonants. Moreover, vowel errors are less frequent than consonant errors in children with phonological impairment (Eisenson & Ogilvie, 1963; Stoel-Gammon & Herrington, 1990). However, according to Pollock and Keiser's (1990) study of 15 children with moderate-to-severe phonological impairment, vowel errors may occur in as many as 50% of children with phonological disorders. Recently, there are increasing attention of vowel errors from researchers and practicing clinicians of speech therapy.

The growth of vocal tract and its relationship with the development of speech is a complicated process. The relationship between anatomical differences and the differences of speech production would be best studied in vowel production. It is expected that the vowel formant frequency will decrease as vocal tract length increases (Fant, 1960). Moreover, because boys have a larger vocal tract than girls, there are differences in formant frequencies between preadolescent boys and girls. Perry, Ohde, and Ashmead (2001) and Whiteside and Hodgson (2000) pointed out as early as four years old, boys are found to have lower formant frequencies than those of girls. These gender differences in the formant values are attributed to various dimensions of anatomic changes.

Studies on early vocalic production in both qualitative and quantitative changes can provide more accurate norms for evaluating and helping in the early identification of articulation disorders (Ertmer, 2001). Currently available clinical screening tests for children are based on the occurrence of consonants and vowels in the identifiable words they produce (Selby, Robb, & Gilbert, 2000). These tests are not applicable to infants or children who produce no or few identifiable or meaningful utterances. Studies on early vocalic production can help to establish norms for young children and to develop appropriate screening tests for this population. These studies are particularly important in identifying subtle differences in vocalic utterances, which are not readily detectable by human ear, in phonological disordered children to establish definable guideline and to set up goals for speech therapy.

II. METHODOLOGY

In this longitudinal study, vocalizations of 2 Mandarin-learning children (Subject A, a boy; Subject B, a girl) were audio recorded (once every 3 months, from birth to 5 years old) during observations of their natural daily activities in their homes. An average of 45 minutes of recordings was made from each of the two-hour observation sessions for each child.

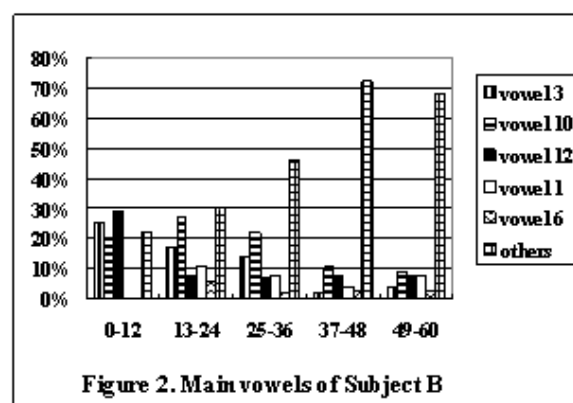
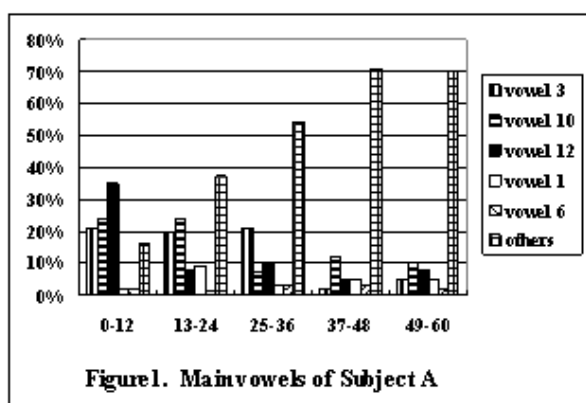
A wireless lapel microphone was linked to a Sony DAT recorder with a

signal-to-noise ratio above 91 dB. The DAT recorder was used for playback in perceptual transcription and acoustical analysis. All spontaneous productions of V or CV syllables were then digitally recorded into a computer using Computerized Speech Lab (Kay CSL 4400). The sampling rate was 48,000 samples per second. Broadband and narrowband spectrograms were generated for each token by adjusting analysis size. The cursor was moved to the steady portion of each spectrogram and a Fast Fourier Transform (FFT) was generated with Linear Predictive Coding (LPC) overlaid on the Fourier spectrum. The frequency values of the first and the second formants of the vowels were measured with reference to the four displays: narrowband spectrogram, broadband spectrogram, FFT, and LPC.

III. FINDINGS AND DISCUSSION

DEVELOPMENT OF VOWEL CATEGORIES

Almost all of the single vowels in Mandarin appear and they are evenly distributed except for the late-acquired /y/. This high-front rounded vowel is still less frequently found in the fifth year in both Subject A (boy) and Subject B (girl). The corner vowels /i/ and /u/ are used more frequently during the fourth year and show similar frequency of occurrence as other single vowels. In the fifth year, these two vowels show steady frequency in both subjects and have obvious increase of frequency in the second half of the fifth year in Subject B. Although the low vowel /a/ shows high frequency of occurrence during the first three years, for Subject B, it is not used more frequently than most of the single vowels in the fourth year. In the fifth year, the frequency of this vowel continues to decrease. However, for Subject A, in the fourth year, the low vowel /a/ is still prominent as was found in the previous three years. Not until the fifth year, the decrease of relative frequency of this vowel is found. This is one of the major differences between the development of these two subjects.



Vowel 3 /ɛ/, Vowel 10 /a/, Vowel 12 /ə/, Vowel 1 /i/, Vowel 6 /u/

Diphthongs show high frequency at this stage as the previous stage (4 years old), and almost all of the diphthongs in Mandarin are found. This development indicates that children at this stage have acquired better speech motor control and timing control in moving from the position of one vowel to the other for producing diphthongs. Both diphthongs with on-glide (e.g., /aɪ, aʊ/) and

with off-glide (e.g., /aɪ, aʊ/) appear in both subjects' production. However, /e, o/ are still rarely found, especially /o/, in both subject probably due to the influence from the input of Taiwanese Mandarin.

The frequency of vowels with nasal endings shows prominent increase at this stage. There is a steady increase of this vowel category in both genders. Due to the increase of vowels with nasal endings, the frequency of diphthongs, which is the vowel category of the highest frequency of occurrence in the previous stage (4 years old), shows relatively lower frequency in this stage. The difference of the frequency between these two vowel categories diminishes drastically, and thus these two categories show similar frequency of occurrence in this stage.

In addition, the triphthong /ɪaʊ/ was found in the third year and is prominent (among the top two frequently used vowels) in the first half of the fourth year in Subject A. However, it is less prominent by the end of the fourth year due to increase of vowel varieties. This tendency persists in the fifth year. For Subject B, this vowel starts to be used frequently from 3 years and 9 months and shows the highest frequency of occurrence (12.92%) among all the vowel categories by the end of the fourth year. Up until the second half of the fifth year, the frequency of this vowel has a prominent decrease in Subject B.

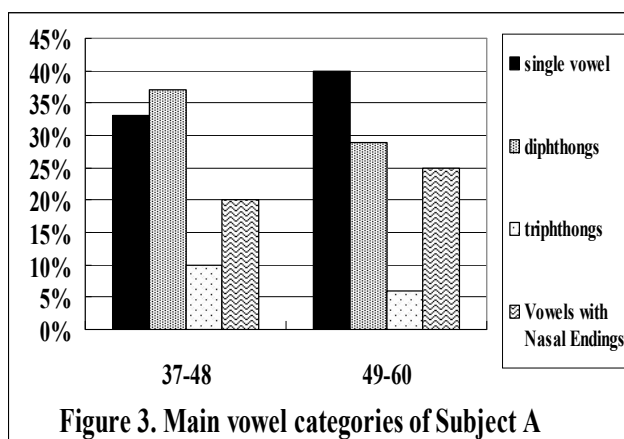


Figure 3. Main vowel categories of Subject A

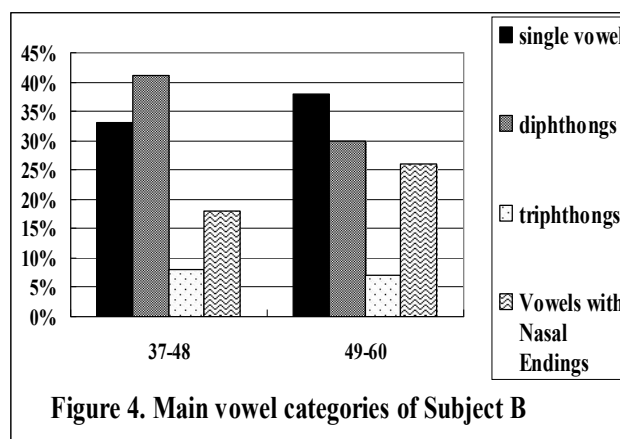
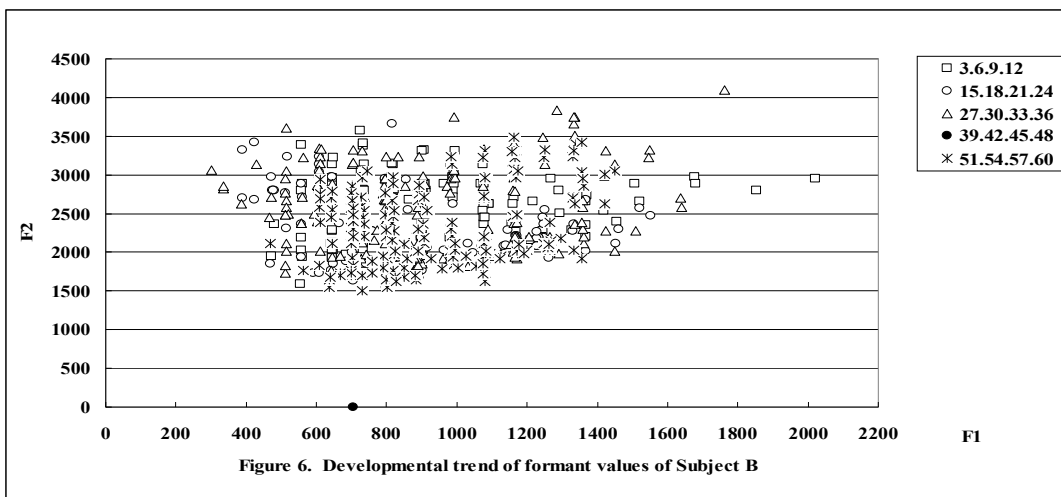
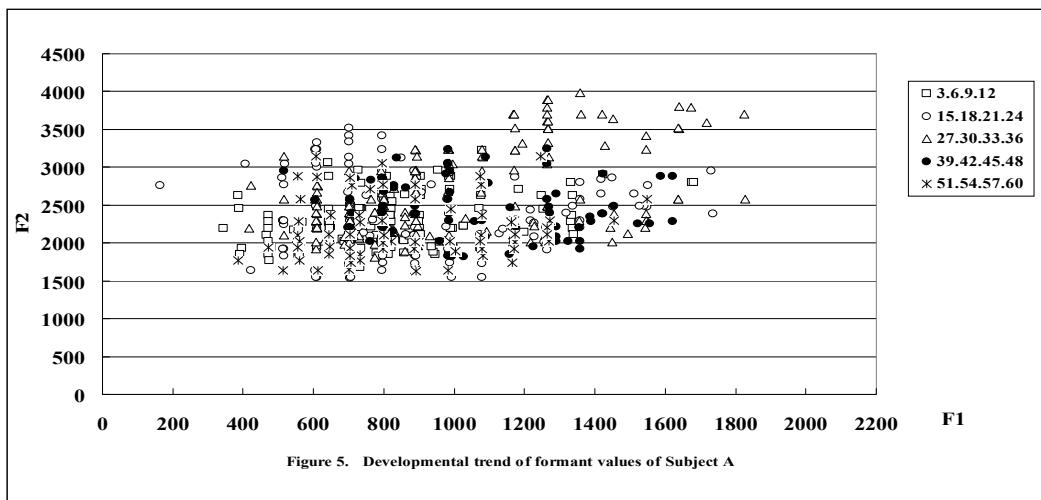


Figure 4. Main vowel categories of Subject B

CHANGES OF FORMANT FREQUENCIES

In the previous report, we found that, like what was found in Perry, Ohde, & Ashmead (2001) and Whiteside & Hodgson (2000), from 3 years and 6 months, the boy subject (Subject A) shows relatively lower vowel formant values than girl subject (Subject B), reflecting gender differences in the development of vocal tract. This trend is continuously observed in this stage. The differences are found in the average values for all the vowels and are also prominent in the development of /a/ and /ɔ/. In Subject A, the average values of F1 decrease from 723Hz to 515Hz and F2 from 2096Hz to 1361Hz during the fifth year, while no tendency of decrease in formant values is found in Subject B (on the contrary, increase of formant frequencies is observed). Regarding the developmental trend of the four stages in the fifth year, another obvious decrease of formant frequencies is from 4 years and 6 months for Subject A, in addition to the abrupt decrease of formant frequencies at 3 years and 6 months found in the previous stage.



IV. CONCLUSION

The vowel production in two Mandarin-learning children was recorded in a longitudinal study from birth to 5 years old. Major findings in the fifth year of development are: 1) Except for /y/, almost all of the single vowels (including corner vowels) in Mandarin appear and they are evenly distributed; 2) All of the diphthongs in Mandarin are found at this stage; 3) In both subjects, vowels with nasal endings are prominent and display similar frequency of occurrence as diphthongs; 4) Triphthong /iəu/ show decrease of frequency in this stage; 5) The girl subjects seem to develop earlier than the boy subject in several aspects: develop more vowel varieties earlier and thus less rely on the early-acquired /a/, new vowel categories are stabilized earlier (vowels with nasal endings and diphthongs); 6) From 3 years and 6 months, the boy subject shows lower vowel formant values, reflecting gender differences in the development of vocal tract. This trend is continuously observed in this stage. In addition to 3 years and 6 months, there is another stage of decrease of frequency at 4 years and 6 months in Subject A. Gender differences in vowel development found in this study can be traced in the following longitudinal observation.

V. ACKNOWLEDGEMENT

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