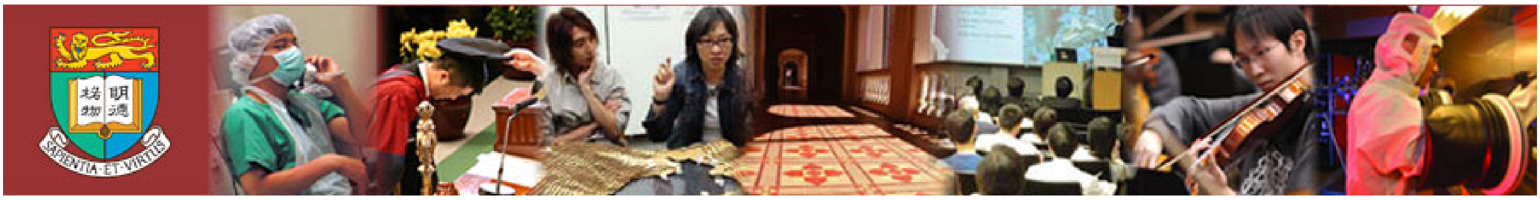

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Perception of English as a Second Language

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Perception of English as a Second Language

Wong Kwai Wah Maggie

Abstract

This study aims to assess the effect of fluent speaking age and schooling experience on one's speech perception ability in English as a second language (L2) under quiet and various noisy situations, addressing relationships between proficiency and speech perception ability in L2, as well as one's speech perception performance under speech spectrum shaped noise and other daily life noises. Hearing In Noise Test (HINT) was administered to native Cantonese speakers with English as L2. Correlations studies were done to investigate the 2 relations suggested above. Result indicated that attainment of fluent speaking in L2 at an early age with intensive amount of native L2 input are important for L2 speech perception ability at least under the presence of background noise and it can be predicted from one's L2 proficiency, yet predictions of performance in other types of noise based on performance in speech spectrum shaped noise cannot be made.

Perception of English as a Second Language

In the past centuries, researches have been conducted regarding how different variables (age of L2 learning, forms of L2 education and L2 proficiency) affect L2 acquisition.

The Effect of Age

The belief of “the earlier, the better” for L2 acquisition is rarely violated in studies of speech perception. What remains controversial is the nature of age effect on speech perception. The Critical Period Hypothesis (henceforth CPH) suggests that L2 acquisition should occur during the critical period before puberty, after which one’s L2 learning ability sharply decline due to the loss of plasticity in neural organization (Lenneberg, 1967). CPH advocates claimed that children below 6 could acquire L2 without foreign accents, while children from 6 to 12 possessed various degrees of foreign accent (Long, 1990, as cited in Flege, 1999). Another hypothesis, the Speech Learning Model (henceforth SLM), assumes phonetic learning ability remains intact throughout one’s lifespan, and suggests that the age factor would gradually affect one’s L2 proficiency (Flege, 1995).Flege, Muniro, and Makey (1995, as cited in Flege, 1999) stated the perceptual rating of immigrants’ native Canadian accent gradually decreased as their arrival age increased.

The effect of age on L2 speech perception has been further studied under different listening conditions (i.e. the degree of noisiness). Mayo, Florentine and Buss (1997) have conducted a cross-sectional study with the finding that native speakers performed better than early bilinguals, while early bilinguals performed better than late bilinguals, in terms of L2 speech perception ability under high level of noise. Lin, Chang, and Cheung (2004) stated that in the presence of background noise, the earlier one began to learn a L2, the better his/her auditory perception of English minimal pairs was. More effective use of contextual cue to perceive words which were totally masked or partially masked by noise (Mayo et al., 1997), as well as the presence of categorical mode in human auditory systems (Wode, 1994) were the main reasons for higher speech-understanding ability of young L2 learners.

The Effect of Schooling Experience

Flege and Liu (2001, as cited in Piske, 2007) suggested the effect of formal L2 instruction with native speakers was prominent in learning L2 pronunciations as chances were provided for students to receive a large amount of L2 input from native speakers at school. Their experiments revealed that early bilinguals who learnt L2 from native L2 speaker at school, compared with late bilinguals who started L2 learning after school age, performed more successfully in tests of both L2 speech production and perception.

Language proficiency in relation to L2 learning

According to van Wijngaarden, Steeneken and Houtgast (2002), L2 proficiency was a good predictor towards non-native listeners' intelligibility in speech perception. Their study on a group of Dutch showed that language proficiency in their L2, including English and German, ranging from reasonable to excellent level, would need 1-7 dB better signal to noise ratio better to achieve 50% sentence intelligibility when compared with native listeners. The study also suggested that in L2 speech perception, the highly proficient non-native listeners could make more “near-native” use of subtle phonetic cues and contextual constraints (such as semantic cues) than the lowly proficient population. (van Wijngaarden et al., 2002)

Aim of the present study

Previous researches have shown that L2 speech perception is affected by age, formal L2 instruction, and L2 proficiency. This study will further investigate Cantonese-English bilinguals’ speech perception of English as a L2, with below three main focuses:

Firstly, this study will explore the nature and extent of the effect of language experience on the speech perception of English as a L2 for Cantonese-English bilinguals who are living in Hong Kong. To find out how the age factor affects L2 speaking fluency, Mayo et al. (1997) compared two groups of bilinguals: learning fluent L2 before age 5 and after age 14. To further investigate the same issue, participants in this research are divided into three groups (aged 5 or below; between 6 and 14; aged 14 or above). Whether the age effect is only salient under noisy conditions is studied by having participants conduct the tests under different listening conditions.

For schooling experience, participants are divided into two groups, local English-medium instruction (EMI, hereafter) school students and international school students, to find out if one’s speech perception performance is affected by schooling experience (i.e.

with or without native L2 teachers in L2 formal instruction). Hong Kong parents greatly concern about the language medium of teaching, which directly affects the effectiveness of school education towards children's non-native language ability.

For relationships between L2 proficiency and speech perception, previous researches determined one's L2 proficiency through linguistic tasks (such as Boston naming test in Silverberg & Samuel's study in 2004). This study uses, self-reported L2 proficiency, a reliable predictor of L2 performance (Marian, Blumenfeld, & Kaushanskaya, 2007).

Secondly, previous researches stated that one's speech perception ability in L2 was lower than that in his/her first language (L1), implying communications was less effective in non-native speech than in purely native speech (van Wijngaarden et al., 2002). This research will further investigate differences between speech perception abilities in English and Cantonese under various noise environments for Cantonese-English bilinguals.

Thirdly, in previous research, both daily life noises (i.e. aircraft noises, competing talker babble noise) and artificial noises (i.e. speech spectrum shaped noise) were used to investigate the L2 speech perception ability of non-native speakers in noisy conditions (e.g. Lin et. al., (2004);Mayo et. al., (1997)). However, one's performance might be affected as the spectral and temporal characteristics in various noise samples were different (Ng, 2006). Therefore, in this study, the relationship of one's L2 speech perception performance with artificial noise and daily life noises is studied by having participants conduct tests under artificial noise (speech spectrum shaped noise) and daily life noises (four-talker babble, MTR and café noises).

To achieve the above purposes, a cross-sectional study is conducted by recruiting students bilingual in English and Cantonese. These students either attend international (with mostly native English teachers) or local EMI schools (with mostly non-native English teachers). Their speech perception ability in Cantonese and English is measured using clinical protocols; they are the Cantonese and English modules of the Hearing In Noise Test (HINT). In this test, sentence level stimuli of equal difficulty level are used to study L2 speech perception. According to Wong and Soli (2005), most stimuli used for L2 speech perception in previous studies were monosyllabic materials or phonemic materials that lack redundant information that was usually present in conversational speech. The results obtained from this study will show how the participants perform in L2 speech perception using sentence level stimuli.

Methodology

A. Materials

1a. Test stimuli

The 12 20-sentence lists in English module (HINT, hereafter) and Cantonese module (CHINT, hereafter) of Hearing In Noise Test were the target stimuli in this study. These lists were randomly selected to be presented binaurally. Practice speech sets were presented preceding the test. Speech perception ability in Cantonese and English of all listeners was measured in Reception Threshold for Sentence (RTS) that calculates in dB, and was defined as the presentation level needed for a listener to recognize the sentence materials correctly 50% of the time (Wong & Soli, 2005).

Three common real life noises (4-talker babble, café and MTR noise) and two speech spectrum-shaped noises (CHINT and HINT noise) were used in the test. All noises were originated from the front direction presented with speech. The multi-talker background noise of 4-talker babble in both Cantonese and English were produced by 2 females and 2 males. Two environmental noises, recorded in a MTR carriage and café, were used. The naturalness of the environmental noises were rated for each real life noises to ensure the background noises were highly typical and representative (Ng, 2006).

1b. Reliability measures of the test

An examination on inter-list reliability was conducted in the development of CHINT (Wong & Soli, 2005) and HINT (Nilsson, Soli, & Sullivan, 1994). Similar results (in terms of RTS) suggested high inter-list reliability led to good test-retest reliability as re-tests often used different lists. Norm referenced comparisons could be made using the two modules of HINT (Wong & Soli, 2005). (See Table 1)

2. Language Experience and Proficiency Questionniare (LEAP-Q) (Marian et al., 2007)

LEAP-Q (See Appendix A) was designed as a valid, reliable and efficient self-reported questionnaire to assess how bilingual subjects' language profiles was affected by age of L2 acquisition, duration of L2 exposure, one's language proficiency, the degree of each contributive factors to L2 and degree of L2 exposure (Marian et al., 2007). A Chinese version of LEAP-Q was also available (See Appendix B). It was also translated into Chinese version in this research by a university graduate of Bachelor of Arts with major in English Studies and Translation and reviewed by a native Cantonese speaker to check if the questionnaire was comprehensible and naturally written in Chinese. The language proficiency rating scale was from 0 (none) to 10 (perfect); the degree of each L2 contributive factors is from 0 (not a contributor) to 10 (the most important contributor); the degree of L2 exposure in different context is from 0 (never) to 10 (always).

Table 1. The normative data of HINT results in American English and Cantonese modules under quiet condition (expressed in dBA) and noise front condition (expressed in dB S/N)

	Quiet		**Noise Front**	
Language	**Mean**	**Std Dev**	**Mean**	**Std Dev**
American English	15.6	3.1	-2.6	1.0
Cantonese	19.4	3.1	-4.0	0.9

B. Participants

Participants were 50 normal-hearing listeners (21 males and 28 females), aged from 16 to 20 (M = 17.08, SD = 0.99), whose L1 was Cantonese and L2 was English. 25 of them were educated in international schools while others in local EMI schools. Their language experiences and proficiency were self-reported in the LEAP-Q. (For detail, see Appendix C & D)

Similar to international school students, who acquired L2 at the age of 2.5 in average, local EMI school students learnt L2 at the age of 2.8 on average. The attainment of L2 fluency was later for local EMI school students; international school students gave higher ratings in reading, understanding and speaking than local EMI school students in average. In addition to being divided by half into local EMI and international school, students were divided into three groups by their age at which their English became fluent to study effects of the age of L2 acquisition, so as to study the effects of schooling experience. The early childhood bilingual (ECB) group included 9 students who claimed to attain fluent English before age 6. The Childhood to Puberty Bilingual (CPB) group consisted of 36 students who claimed to attain fluent English between age 6 and 14. The After Puberty Bilingual (APB) group included 5 participants who acquired fluent English after age 14.

All participants had normal hearing, as confirmed by having audiometric pure tone air-conduction thresholds better than 25dB HL at the frequencies at 500,1000, 2000, and 4000 Hz in both ears. No current or previous history of hearing impairment was reported.

C. Equipment

Participants attended the test in a sound-treated booth in the Standard Chartered Community Foundation Hearing Centre of the University of Hong Kong. The sentence list and speech spectrum noise in CHINT and HINT were delivered by the HINT program (version 5.05) connected to a MADSEN itera II clinical audiometer. A Sony compact disc player CDP-XE200 was used to play daily-life noises. Allen & Heath GR1 sound mixer were used to mix speech and noise stimuli before being played by TDH 39 headphone. Bruel & Kjaer Type 4144 sound level meter was used for speech and noise levels calibration. The output of speech spectrum noise, daily-life noises and speech stimuli was calibrated in 6 cc coupler on a weekly basis to 65 dB SPL under headphones.

D. Procedures

The experiment lasted for about 1 1/2 hours, including a hearing assessment, Hearing In Noise Test in English and Cantonese module and self-reported language questionnaire.

Hearing Assessment

The standard clinical hearing assessment including pure tone audiometery, otoscopic examination, tympanometry and a simple case history was conducted before the experiment to ensure participants would meet the criteria of the test.

English and Cantonese modules of Hearing In Noise Test (HINT and CHINT)

HINT and CHINT were administered by presenting sentences in English and Cantonese, in quiet and various noisy conditions, to participants through headphones. They were asked to listen to the sentences carefully and repeat the sentence verbally as accurately as possible. The presentation levels of sentences in quiet and noisy conditions were set at 25 dBA and 65 dB

SPL respectively, while the presentation of all noises was set at 65 dB SPL in headphones. The sound pressure level of the sentence was adjusted with regard to participants' performance using an adaptive procedure.

Both HINT and CHINT with 20-sentence list were introduced to participants in random by alternating the order of these two modules. In each module, participants were firstly presented with a practice list in quiet condition so they became more familiar with the speaker's voice and the listening task. Then, five test lists were presented to participants under five listening conditions, including quietness, three common real life noises and a steady speech spectrum-shaped noise (CHINT noise/ HINT noise). The sequence of the listening conditions and the sentence lists were presented in random.

After each condition, the receptive threshold of sentences (RTS), defined as the SNR in dB, for a listener to recognize the sentence materials correctly 50% of the time, was obtained using Noise Front condition in CHINT and HINT paradigm.(Nilsson, Soli, & Sullivan, 1994; Wong & Soli, 2005). For results in quiet conditions, the RTS was expressed in dBA.

Self-reported language questionnaire

Normal hearing listeners were asked to fill out LEAP-Q, either in English or Chinese, to evaluate their own language experience. Demographic information and medical histories as relevant to ear pathology and language learning were collected.

E.Data analysis

A statistical analysis package SPSS version 16.0 for Windows was used. To investigate how ability in understanding English was affected by L2 experience, the factorial analysis of variance (ANOVA), a 2*3*2*5 design (types of school* age of fluent speaking* language modules of HINT* listening conditions), was performed on the sentence reception threshold (RTS), which measured in dB(A) for quiet condition or in signal-to-noise ratio (dB S/N) for noise conditions. Two between-subjects factors were types of school (local or international school) and age of fluent speaking (aged 5 or below; 6-14; 15 or above). The within-subjects variables were language modules of HINT (English and Cantonese modules) and five listening conditions (quietness, speech spectrum noise, 4-talker babble, Café and MTR noises). The main effects and interaction effects were considered significant when $p<0.01$. When an interaction effect was found to be significant, one-way ANOVA would be performed. To explore the source of significant effects as indicated by ANOVA, post-hoc analysis was conducted; i.e. pair-wise comparison was conducted on a within-subject factor while Tukey's test was performed on a between-subject factor. The difference was taken as significant when its significant level (p-level) was equal to or smaller than 0.05.

Correlation analyses were conducted to assess the relationships between self-reported L2 proficiency and English speech perception ability under quiet and noisy situations. The relationship between speech perception ability in a speech spectrum shaped noise and daily-life noises was also examined. Furthermore, simple linear regression analysis was conducted to show the predictive power of a particular performance over another performance.

Results

According to the data analysis approach designed in this study, we will discuss the result in the following areas:

1a. Relationship between L2 experience (i.e. types of schools and age of fluent speaking) and L2 perception under different listening conditions

The effect of L2 experience on L2 perception was examined through a factorial ANOVA (2 types of school * 3 age groups of fluent speaking * 2 language modules * 5 listening conditions). Results revealed significant effects of age of fluent speaking [$F(2, 45) = 10.17$; $p<0.01$], language module [$F(1, 45) = 121.98$; $p<0.01$] and listening conditions [$F(4,180) = 1278.7$; $p<0.01$]. Significant interaction between language modules and types of school was also identified [$F(1, 45) = 13.607$; $p<0.01$]. Interaction effect between language module and age of fluent speaking was found to be significant. [$F(2, 45) = 5.532$; $p<0.01$]. Statistical analysis also showed that the interaction effect between listening conditions and language modules was significant [$F(4,180) = 7.926$; $p<0.01$], which would be further discussed later.

Since there was interaction effect between language module and age of fluent speaking, we would investigate the effect of fluent speaking age in both Cantonese and English modules.

In each language module, five one way ANOVA tests were conducted for effects of fluent speaking age on RTS score under quietness, 4-talker babble, café, MTR and speech spectrum shaped noises. In Cantonese module, no significant difference in age of fluent speaking groups was found in RTS score. However, in English module, the effect of fluent speaking age was insignificant in quiet condition while significant differences were indicated in all noisy conditions except four talker babble noise: speech spectrum noise [$F(2, 47) = 11.49$, $p<0.01$]; MTR noise [$F(2, 47) = 5.49$, $p<0.01$]; Café noise [$F(2, 47) = 9.26$, $p< 0.01$]. (For detail, please see Appendix E).

To simplify the analysis, two one-way ANOVA tests were conducted to investigate the effect of age of fluent speaking on RTS score in quiet and averaged noisy conditions (averaging the RTS score from the four noisy conditions). Similar results showed that significant differences among the groups was present in averaged noisy condition [$F(2, 47) = 10.35$; $p<0.01$] but not in quiet condition [$F(2, 47) = 4.81$; $p>0.01$].

Under averaged noisy condition, the bilinguals who learnt fluent English at age 5 or before (ECB) gained significantly better RTS score than those aged 6-14 (CPB) and 15 or above (APB)with $p <0.05$. The RTS score was also found to be significantly smaller for the group of age 6-14 than of age 15 or above (see table 2).

For the factor of schooling experience, we would investigate the effects of types of school in both Cantonese and English modules. In each language module, five one-way ANOVA tests were conducted for effects of school types under quiet and other noisy conditions. In English module, the results revealed that the effects of school types were significant in all conditions: quietness [$F(1,48) = 18.53$, $p<0.01$]; speech spectrum shaped noise [$F(1, 48) = 14.48$, $p<0.01$]; four talker babble [$F(1,48) = 20.78$, $p<0.01$]; MTR noise [$F(1, 48) = 21.58$, $p<0.01$]; café noise [$F(1,48) = 12.09$, $p<0.01$]. In Cantonese module, no significant effect was revealed in all conditions. Participants from international schools obtained better RTS score than those from local EMI schools significantly (see table 3).

Table 2. RTS score for students with different age of fluent speaking in American English modules of HINT in quiet (in dBA) and averaged noisy conditions (in dB S/N)

Listening conditions	**Age of fluent speaking**					
	Age 5 or before (ECB)		**Age 6-14 (CPB)**		**Age 15 or after (APB)**	
	Mean	SD	Mean	SD	Mean	SD
Averaged Noisy	2.04	1.05	4.86	3.03	9.45	3.95
Quiet	24.2	3.42	27.6	5.06	32.3	4.08

Table 3. RTS score of participants' in local EMI and international school students in American English modules of HINT in quiet (in dBA) and noise conditions (in dB S/N)

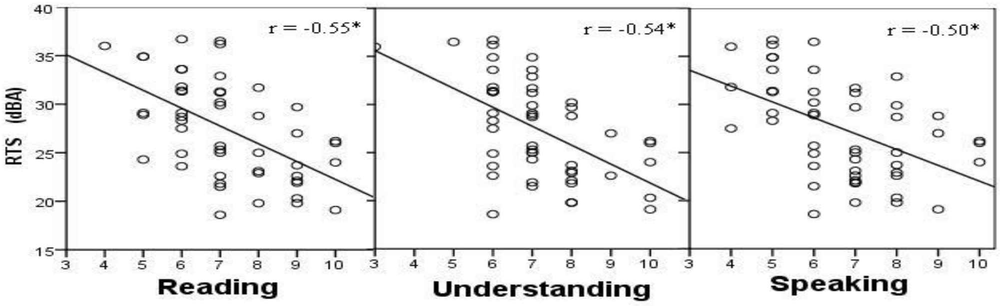
Listening conditions	**Types of school**			
	Local EMI school		**International school**	
	Mean	**SD**	**Mean**	**SD**
Quiet	30.1	5.08	24.8	3.52
4-talker babble	10.1	3.98	5.32	3.42
Café	7.60	4.13	4.14	2.76
MTR	5.3	3.76	1.08	2.55
Speech spectrum shaped noise	4.18	3.98	0.80	1.94

1b.Relationship between the self-reported L2 proficiency and 50% correct in L2 under noise and quiet conditions

Pearson's R correlation analysis was conducted to assess relationships between self-reported language proficiency and RTS score. Results revealed moderate and significant negative correlation ($p<0.01$) among self-reported proficiency in speaking, understanding and reading, and RTS score in averaged noisy and quiet conditions, suggesting those with better self-reported proficiency had better RTS score in noisy and quiet conditions.

The scatter-plots of corresponding regression lines which were fit by method of least square were shown in Figure 1a (under quiet condition) and 1b(under averaged noisy conditions), from which we could see how self-reported L2 proficiency score related with RTS score in a wide range of variations. The correlation under different listening conditions was moderate, reflecting a normal phenomenon that the perceptual judgment of self-rating was various with the subjects' actual ability.

(a)



(b)

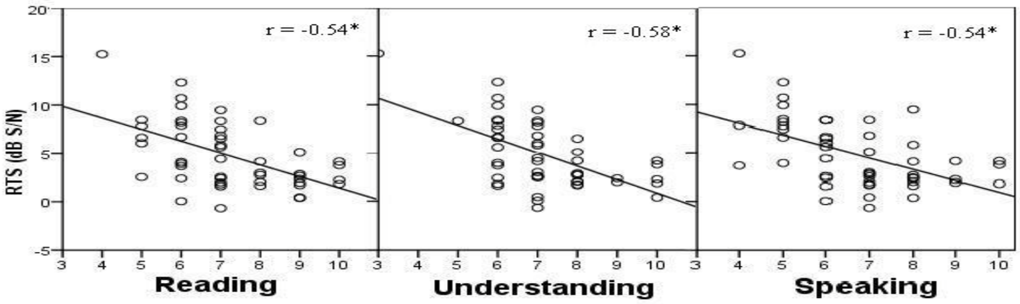


Figure 1. The regression line with the scatter plots of data for prediction of L2 proficiency on RTS score under (a) quiet condition and (b) averaged noisy condition. Stars (*) indicate significant correlation with p<0.01

2. Differences of speech perception abilities in English and Cantonese under quiet and noisy situations

The factorial ANOVA showed significant interaction effect between language modules and listening conditions. Significant differences were found between speech perception abilities in English and Cantonese [F (1, 45) =121.98; p<0.01]. A pair-wise comparison was also performed, and the RTS score in Cantonese was significantly better than those in English module.

The effect of listening conditions was significant [F (4,180) = 1278.7; p<0.01]. Participants' performance of speech perception in both Cantonese and English modules followed the order from the worst performance, under 4-talker babble noise, café noise, MTR noise, to the best performance under speech spectrum shaped noise. (See Table 4)

Table 4. The mean Receptive Threshold of Sentence (RTS) score in American English and Cantonese modules in quiet (in dBA) and noise conditions (in dB S/N)

Listening conditions	Receptive Threshold of Sentence score			
	Cantonese module		English module	
	Mean	SD	Mean	SD
Quiet	20.4	2.3	27.4	5.1
4-talker babble	4.46	1.7	7.71	4.4
Café	1.12	2.0	5.87	3.9
MTR	-1.97	2.0	3.19	3.8
Speech spectrum shaped noise	-3.64	0.9	2.49	3.5

3. Relationship between RTS score in speech spectrum shaped noise and daily-life noises in Cantonese and English module of HINT

Since RTS has been normally measured in speech spectrum shaped noise, its association with the subjects' ability to hear in daily life noises was further examined here. In Cantonese module, RTS scores in speech spectrum shaped noise, of subjects either form international or local EMI schools, did not correlate well with those in daily-life noises ($p>0.01$). On the contrary, in English module, only local EMI school students' RTS score in speech spectrum shaped noise was highly correlated with those in daily-life noises with p-level<0.01. Relationships of participants' RTS scores in speech spectrum shaped noise and in daily life noises were illustrated in the scatter-plots with regression line in Figure 2a and 2b. The regression lines were fit by method of least square. The plots showed that RTS scores in speech spectrum shaped noise generally increased with other daily life noise in English module; while such relationship was not shown in Cantonese module.

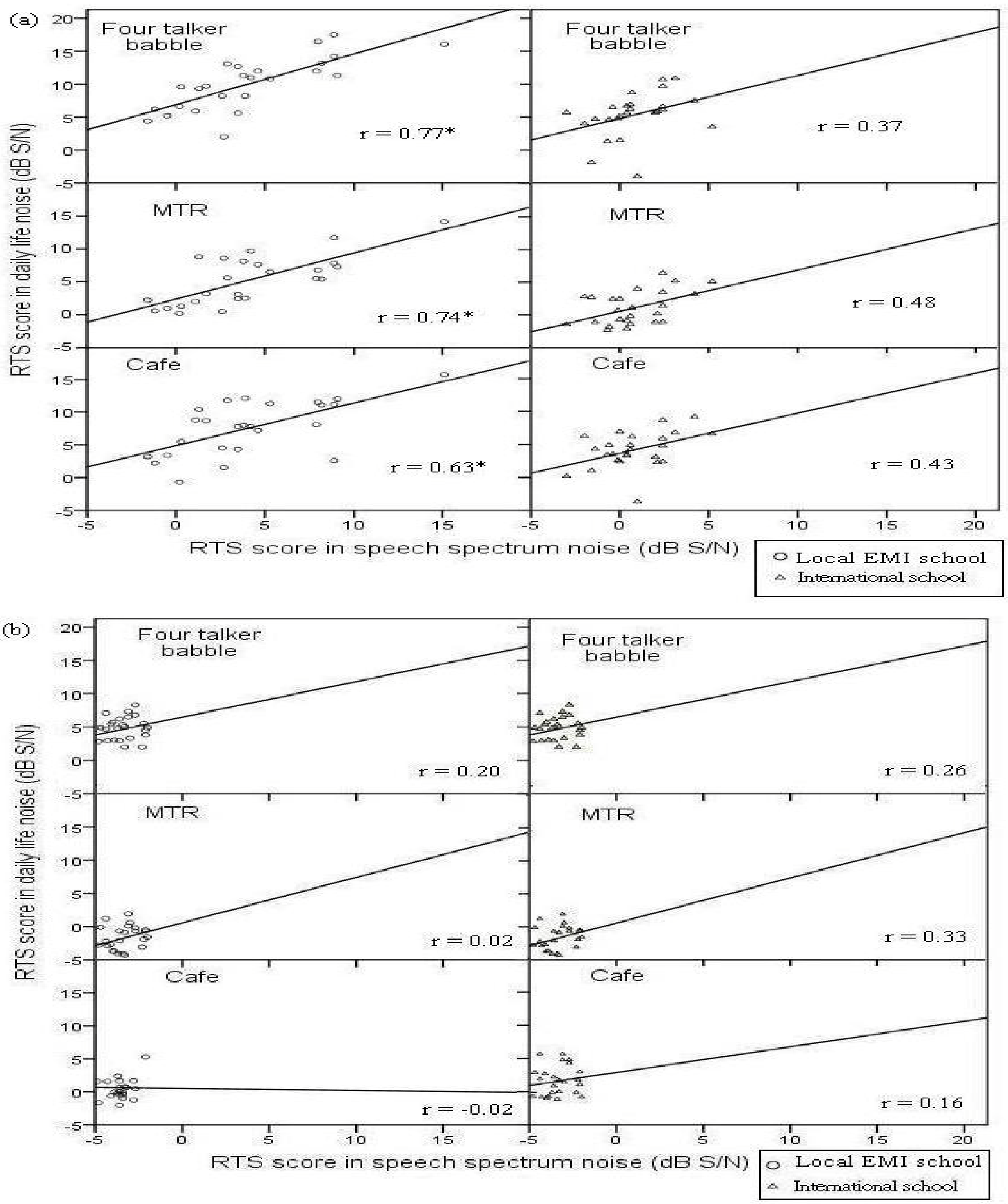


Figure 2. Relationship between the RTS score in dB SNR in speech spectrum shaped noise and daily life noises in (a) English module and (b) Cantonese module. Stars (*) indicate significant correlation with $p<0.01$.

Discussion

The above results clearly showed one's speech perception ability, in terms of RTS score (in English module only) was significantly affected by fluent speaking age and school type. One's self-reported L2 proficiency was also related to L2 speech perception ability. The significant effect in one's speech understanding performance under speech spectrum shaped noise and real life noises was only seen in L2 (i.e. English) for local (but not international) school students. The relationship was not significant in L1 (i.e. Cantonese) for both local and international school students.

To answer questions raised in introduction, below discussion is divided into three parts:

1a. The nature and extent of the effect of L2 experience on speech understanding under quiet and various noise situation using sentence level stimuli

As designed, participants were divided into three groups on the basis of L2 fluent speaking age and two groups on the basis of school types.

Effect of age of L2 fluent speaking on speech perception ability

In English module, the effect of age of L2 fluent speaking on speech perception ability was obvious in participants' performance in HINT under averaged noisy (but not quiet) conditions. Table 2 showed that ECB (aged 0-5) performed much better than CPB (aged 6-14); while CPB performed much better than APB (aged 15 or above). This agreed with the conclusion suggested by Mayo et al (1997) that the earlier one learnt L2, the better his/her L2 speech perception ability was. Our research here further showed that one's ability in L2 speech perception decreased gradually as the age of fluent speaking in L2 increased.

Sentence level stimuli revealed two main reasons why the factor of age of fluent speaking was only salient in noisy but not in quiet situations. One reason was the effectiveness in using of semantic redundancy as contextual cue in sentence stimuli, supported by the belief that linguistic redundant information (e.g. semantic redundancy) might be important in one’s speech perception in sentence level stimuli (Wong & Soli ,2005; van Wijngaarden et al., 2002). For example, in terms of word position, words at the end of a sentence were more redundant than words at the beginning of a sentence, due to the presence of semantic constraints (van Wijngaarden et al., 2002). As a result, younger L2 learners could acquire more efficient high-level processing, making use of this contextual cue (i.e. semantic redundancy) totally or partially masked by noise (Mayo et al., 1997).

Another reason agreed with the central claim of SLM suggested by Flege (2002), that L2 speech learning would become increasingly more difficult when one learnt L2 at a later age and the phonetic space in human auditory system became more committed to L1. This might be further explained by the presence of category mode for speech perception in which the phoneme discrimination was based on the perceptual category boundary set (Wode, 1994). This mode would become language specific at a young age, and became less accessible for non-native languages at a later age. According to Fung (2004), the perception of speech was different in Cantonese and English. For example, there were only voiceless plosives in Cantonese, and aspiration contrast was used to discriminate the plosives (/p/vs /p$^{h/}$, /t/vs/ t^{h} /,

/k/vs /k^h/). Human auditory system was thus divided into different categories for the perception of plosives based on the Voice Onset Time difference between aspirated plosives and unaspirated plosives in Cantonese. Since plosives in English were discriminated by voicing contrasts, which were absent in Cantonese plosives, they were categorized into different speech perceptual categories based on VOT differences between voiced and voiceless plosives (/b/ vs /p/, /d/ vs /t/, /g/ vs /k/). Such differences led to difficulties of Cantonese speakers, who learnt English at a later age, in perceiving voicing contrasts of English plosives in their perceptual category for speech understanding. L2 speech perception thus became worse gradually while the age of fluent speaking increased (Flege, 1999; Wode, 1994), especially when one's auditory system was processing under noisy situations (Mayo et al., 1997). According to Piske (2007), there were also other contributing factors which affected L2 learners' competence, such as school types.

Effect of school types on speech perception ability

School type was found to have significant effect on participants' performance of speech understanding in English (but not in Cantonese) module in both quiet and noisy situations. For RTS mean, international school students (in quietness: M = 24.8, SD = 3.52; in speech spectrum shaped noise: M = 0.80, SD = 1.94) scored higher than local EMI school students: (in quietness: M = 30.1, SD = 5.08; in speech spectrum shaped noise: M = 4.2, SD = 3.98). These two groups of students were recruited within the same age range and level of education.

With controlled age and level of education of participants, the effect of native L2 teacher in formal instruction shown matched Flege and Liu's idea (2001) that a foreign language classroom providing formal L2 instruction with native L2 teachers ensured extensive and high-quality L2 input from native English speakers to L2 learners, which played an important role for L2 learners to perceive and produce L2 sounds more accurately (Piske, 2007).

Based on above-mentioned effect of age and schooling experience, clinical implication, as described by Wesche (2002, p. 362 as cited in Piske, 2007), suggests an early immersion teaching approach, using L2 as a teaching language with native L2 teachers for school curriculums, was the most effective mean of L2 instruction in school, as it entailed three important contextual features in early immersion teaching approach; early L2 learning age, intensive native-like L2 input amount and activities using L2 as a media at school all motivate students to use and understand L2 (Piske, 2007) . To help students achieve success in L2 learning, parents, teachers and school administrator should carefully choose the teaching language of school curriculum.

Estimated differences in speech intelligibility (%) for speech perception among bilinguals

To examine the extent of the effect of L2 experience on L2 speech perception under quiet and noisy situations, previous researches showed the S/N ratio to quantify differences among bilinguals. In this study, the extent of the effect of L2 experience could be quantified by the estimated difference in speech intelligibility (%) for perception among three groups of bilinguals. According to the slope of the performance-intensity function (P/I slope) of 10.6 %/dB, in speech spectrum shaped noise situation, ECB showed 31% and 84% higher speech intelligibility than CPB and APB respectively. In terms of school types, international school students had 56% better speech intelligibility than local EMI school students in quiet situations; international school students had 36% better speech intelligibility than local EMI school students in speech spectrum noise condition. Clinical implication suggests attention should be paid to the magnitude of reduction in speech intelligibility for students with various L2 backgrounds when designing classroom environments, such as the amplitude of environmental noise level and the speech presentation level of L2 teachers in the classroom.

1b. Relationship between self-reported L2 proficiency and L2 speech understanding under quiet and noisy situations

As expected in this study, significant and moderate correlation was established between self-reported proficiency (speaking, understanding and reading) ratings and L2 speech perception ability, matching suggestion of Marian et al.(2007) and in LEAP-Q that one’s self-reported proficiency was a reliable predictor in different standardized behavioral measures (e.g. oral comprehension). van Wijngaarden et al. (2002) also suggested that L2 proficiency can be used to predict one’s speech perception ability in sentence as the highly proficient non-native listeners can make more “near-native” use of subtle phonetic cues and contextual constraints; therefore self-reported proficiency may be used to predict one’s speech perception ability in further studies instead of other L2 proficiency tests.

2. Differences of one's speech intelligibility in English and Cantonese under various noisy environments for bilinguals

Generally, results revealed that RTS scores were significantly different in English and Cantonese versions of HINT. With Cantonese version, participants' performance in Cantonese under quiet (RTS = 20.4dBA) and noise front position (RTS = -3.6 dB S/N) deviated from the stated norm by less than one standard deviation (see table 1), implying participants' speech intelligibility in Cantonese was within normal range of native speakers. The mean RTS score in English module, on the other hand, in quiet and speech spectrum shaped noise were 27.4dBA and 2.49 dB S/N respectively, deviating largely from the English norm in quiet (RTS = 15.6 dB A) and speech spectrum shaped noise (RTS = -2.6 dB S/N).

According to Wong and Soli (2008, in press), the P/I slope was 10.6 %/dB in English, indicating that participants showed 125% and 54.0% poorer speech intelligibility in quiet and noise front conditions than that of native English speakers respectively. This reduction in speech intelligibility in English was likely to be related with English being a L2.

This result seemed to support the SLM suggested by Flege (1995) that L2 speech learning was more difficult if the learning age increased as the phonetic space had become more committed to L1,while L1 speech perception was not affected as the category mode for speech perception would become L1 specific at a young age (Wode, 1994).

3. The relationship of the bilinguals' speech perception in speech spectrum shaped noise and daily life noises

Result showed that the correlation of one's speech perception performance between speech spectrums shaped noise and daily life noises were trivial in Cantonese module, yet significantly strong in English module for local EMI school students only.

The significant correlation was significant in English module for local EMI school students implies that perhaps we can predict the performance in daily noises based on that in speech spectrum shaped noise. However, the correlation in Cantonese module was small and insignificant which was possibly due to the limited distribution of RTS score in both speech spectrum shaped noise and daily life a noise. Figure 2 showed that one's speech perception ability in speech spectrum shaped noise did not change with that in other daily life noises, and the range of RTS score was limited in Cantonese module. Therefore, due to the above inconsistent result, RTS scores in speech spectrum shaped noise are not recommended to predict one's speech perception ability in daily life noise.

Limitations and Recommendations

There are four recommendations suggested based on the problems and limitations arisen in this study. Firstly, since the sample size of fifty participants in this study was small, individual differences among the participants would become a contributive error to the result of the study. A larger sample size is recommended in order to minimize the individual errors among the participants in future studies. Secondly, in the present study, the presence of category mode for speech perception was used to explain the effect of age of fluent speaking. To further confirm this, studies of phonemic and phonetic recognition in English for native Cantonese speakers with different ages of L2 learning can be focused in further studies. Thirdly, in this research, only the types of school were taken into consideration to study the effect of schooling experience, without measuring the effect of number of years exposed to the corresponding learning environment. Further studies can focus on this to further study the effect of schooling experience. Fourthly, to further study the relationship one’s speech perception under speech spectrum shaped noise and daily life noises, native English speakers can be recruited to participate in the test so as to study the predictive power of the RTS score in speech spectrum shaped noise in other daily noisy situations in English.

Conclusion

Learning fluent L2 at an early age and intensive amount of native L2 input are important for speech perception. The self-reported L2 proficiency is recommended to predict one’s L2 speech perception ability. Yet, prediction of performance in other types of noise based on performance in speech spectrum shaped noise is not recommended.

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Appendix A

Language Experience and Proficiency Questionnaire --- English version

Last Name		First Name		Today's Date	
Age		Date of Birth		Male ☐	Female ☐

(1) Please list all the languages you know **in order of dominance**:

1	**2**	**3**	**4**	**5**

(2) Please list all the languages you know **in order of acquisition** (your native language first):

1	**2**	**3**	**4**	**5**

(3) Please list what percentage of the time you are *currently* and *on average* exposed to each language. (***Your percentages should add up to 100%*)**:

List language here:					
List percentage here:					

(4) When choosing to read a text available in all your languages, in what percentage of cases would you choose to read it in each of your languages? Assume that the original was written in another language, which is unknown to you. ***(Your percentages should add up to 100%*)**:

List language here:					
List percentage here:					

(5) When choosing a language to speak with a person who is equally fluent in your languages, what percentage of time would you choose to speak each language? Please report percent of total time.**(*Your percentages should add up to 100%*)**:

List language here					
List percentage here:					

(6) Please name the cultures with which you identify. On a scale from zero to ten, please rate the extent to which you identify with each culture. (Examples of possible cultures include US-American, Chinese, Jewish-Orthodox, etc):

List cultures here					
List rating here:					
Rating scale:	0: no identification 1: very low identification 2:--- 3:--- 4:--- 5: moderate identification 6:--- 7:--- 8:--- 9:--- 10: complete identification				

(7) How many years of formal education do you have? ___________________________

Please check your highest education level (or the approximate US equivalent to a degree obtained in another country):

☐ Less than High School	☐ Some College	☐ Masters
☐ High School	☐ College	☐ Ph.D./M.D./J.D.
☐ Professional Training	☐ Some Graduate School	☐ Other:

(8) Date of immigration to the Hong Kong, if applicable ____________

If you have ever immigrated to another country, please provide name of country and date of immigration here. ____

(9) Have you ever had a vision problem ☐, hearing impairment ☐, language disability ☐ or learning disability ☐ ? (Check all applicable). If yes, please explain (including any corrections):____

____

First Language(L1): ____________________

All questions below refer to your knowledge of first language (L1)**.**

(1) Age when you…:

began acquiring	*became fluent* in	*began reading* in	*became fluent reading* in :

(2) Please list the number of years and months you spent in each language environment:

	Years	Months
A country where L1 is spoken		
A family whereL1 is spoken		
A school and/or working environment where L1 is spok		

(3) On a scale from zero to ten, please select your *level of* ***proficiency*** in speaking, understanding, and reading

Domain	Rating	Domain	Rating	Domain	Rating
Speaking		Understanding spoken language		Reading	
Rating scale: 0: none 1:very low 2:low 3:fair 4:slightly less than adequate 5:adequate 6:slightly more than adequate 7:good 8:very good 9: excellent 10:perfect					

(4) On a scale from zero to ten, please select how much the following factors contributed to you learning L1:

Factor	Rating	Factor	Rating
Interacting with friends		Language tapes/self instructic	
Interacting with family		Watching TV	
Reading		Listening to the radio	
Rating scale: 0: not a contributor 1:minimal contributor 2:--- 3:--- 4:--- 5:moderate contributor 6:--- 7:--- 8:--- 9: --- 10:most important contributor			

(5) Please rate to what extent you are currently exposed to L1 in the following contexts:

Exposure	Rating	Exposure	Rating
Interacting with friends		Listening to radio/music	
Interacting with family		Reading	
Watching TV		Language-lab/self-instruction	
Rating scale: 0: never 1:almost never 2:--- 3:--- 4:--- 5:half of the time 6:--- 7:--- 8:--- 9: --- 10:always			

(6) In your perception, how much of a foreign accent do you have in L1 ? **please circle the suitable one:**

Rating scale: 0: none 1:almost none 2:very light 3:light 4:some 5: moderate 6:considerable 7:heavy 8:very heavy 9: extremely heavy 10:pervasive

(7) Please rate how frequently others identify you as a non-native speaker based on your accent in L1: **please circle the suitable one:**

Rating scale :0: never 1:almost never 2:--- 3:--- 4:--- 5:half of the time 6:--- 7:--- 8:--- 9: --- 10:always

Second Language(L2): ______________________

All questions below refer to your knowledge of second language(L2)**.**

(1) Age when you…:

began acquiring	*became fluent* in	*began reading* in	*Became fluent reading in*

(2) Please list the number of years and months you spent in each language environment:

	Years	Months
A country where L2 is spoken		
A family where L2 is spoken		
A school and/or working environment where L2 is spoken		

(3) On a scale from zero to ten, please select your *level of **proficiency*** in speaking, understanding, and reading

Domain	Rating	Domain	Rating	Domain	Rating
Speaking		Understanding spoken language		Reading	
Rating scale: 0: none 1:very low 2:low 3:fair 4:slightly less than adequate 5:adequate 6:slightly more than adequate 7:good 8:very good 9: excellent 10:perfect					

(4) On a scale from zero to ten, please select how much the following factors contributed to you learning L2:

Factor	Rating	Factor	Rating
Interacting with friends		Language tapes/self instruction	
Interacting with family		Watching TV	
Reading		Listening to the radio	
Rating scale: 0: not a contributor 1:minimal contributor 2:--- 3:--- 4:--- 5:moderate contributor 6:--- 7:--- 8:--- 9: --- 10:most important contributor			

(5) Please rate to what extent you are currently exposed to L2 in the following contexts:

Exposure	Rating	Exposure	Rating
Interacting with friends		Listening to radio/music	
Interacting with family		Reading	
Watching TV		Language-lab/self-instruction	
Rating scale: 0: never 1:almost never 2:--- 3:--- 4:--- 5:half of the time 6:--- 7:--- 8:--- 9: --- 10:always			

(6) In your perception, how much of a foreign accent do you have in L2? **please circle the suitable one:**

Rating scale: 0: none 1:almost none 2:very light 3:light 4:some 5:moderate 6:considerable 7:heavy 8:very heavy 9: extremely heavy 10:pervasive

(7) Please rate how frequently others identify you as a non-native speaker based on your accent in L2:

please circle the suitable one:

Rating scale: 0: never 1:almost never 2:--- 3:--- 4:--- 5:half of the time 6:--- 7:--- 8:--- 9: --- 10:always

Appendix B

Language Experience and Proficiency Questionnaire ---Chinese version

語文背景及語文能力問卷(LEAP-Q)

姓氏		姓名		日期(今天)	
年齡		生日日期		男 ☐	女 ☐

(1) 請根據常用性順序列出所有你認識的語言 (1 為最常用 5 為最不常用)

1	2	3	4	5

(2) 請按照學習時間的先後順序列出所有你認識的語言(1 為你的母語):

1	2	3	4	5

(3) 請列出於你現在所認識的語言當中，接觸每種語言平均所佔的時間 (以百分比為單位) (以下的百分比總和需相等於 100%):

列出你認識的語言					
百分比(所佔的時間)					

(4) 當你要閱讀一篇文章，而該文章是以你不認識的語言所寫的，請列出你會選擇的(你認識的)語言譯本及你有多常選擇以上的譯本(以百分比作單位) (以下的百分比總和需相等於 100%):

列出你認識的語言					
百分比(所佔的時間)					

(5) 當你跟一個與你各種語文能力一樣的人說話，請列出你會用的(你認識的)語言及所佔的時間(以百分比為單位) (以下的百分比總和需相等於 100%):

列出你認識的語言					
百分比(所佔的時間)					

(6) 請列出各種你所屬的文化 (如美國文化，中國文化，猶太族文化)，並列出你有多屬於以上的文化 (程度級別 0 為完全不屬於， 10 為完全屬於)

各種你所屬的文化					
列出程度					
程度級別	0:完全不屬於 1:很少屬於 2 少許屬於 3:有些屬於 4:介乎有些與屬於之間 5:普通屬於 6:相當 7:好屬於 8:很屬於 9:非常屬於 10:完全屬於				

(7)你接受了多少年的正規教育(如小學，幼稚園，中學)__________________

請選擇你最高的教育程度:

☐ 高中以下 ☐ 大學(尚未完成) ☐ 碩士

☐ 高中 ☐ 大學 ☐ 博士

☐ 專業進修 ☐ 研究生(尚未完成) ☐ 其他(請註明:

(8) 請寫出你開始於香港居住的日子(如適用) ____________________________

如你曾移民到其他國家，請列出國家名稱及移民的日子____________________

(9) 你曾否有以下的殘疾? (於適當的方格加 v)

☐ 視力障礙 ☐ 聽力障礙 ☐ 語文障礙 ☐ 學習障礙

如有，請詳述(包括你如何糾正該障礙):______________________
你的母語: ________________

以下的問題是關於你的母語背景及能力

(1) 請寫出當時的年齡

開始學習:	說話流利:	開始閱讀:	閱讀順暢

(2) 請寫出你於以下的語言環境的逗留時間

	年	月
以你的母語作通行語言的國家		
以你的母語作日常交流的家庭		
以你的母語作日常交流的學習/工作地方		

(3) 請選擇你於會話，理解及閱讀各範疇的能力級別 (0 為不懂 10 為完全掌握)

範疇	級別	範疇	級別	範疇	級別
會話		理解		閱讀	
級別: 0: 不懂 1: 很弱 2: 弱 3: 一般 4: 介乎一般與足夠之間 5: 足夠 6: 介乎足夠與好之間 7: 好 8: 很好 9: 非常好 10: 完全掌握					

(4) 請選舉下列因素對你母語學習的影響級別 (0 為沒有 10 為最大)

因素	級別	因素	級別
跟朋友溝通		語言錄音帶/自我指導	
跟家人溝通		看電視	
閱讀		聽收音機	
級別: 0:沒有 1:很少 2:少許 3:一般 4:介乎一般與中等之間 5:中等 6:介乎中等與大之間 7:大 8:很大 9:非常大 10:最大			

(5) 現有的你有多常於以下情況接觸母語 (0 為從不 10 為常常)

情況	級別	情況	級別
跟朋友溝通		語言錄音帶/自我指導	
跟家人溝通		看電視	
閱讀		聽收音機	
級別: 0:從不 1:差不多沒有 2:少許 3:偶爾 4:間中 5:一半的時間 6:較常 7:通常 8:時常 9:經常 10:常常			

(6)你認為你的母語有多重的外地口音? **請圈出適當的級別:**

級別:0:沒有 1:差不多沒有 2:很少 3:少 4:有些 5:中等 6:相當 7:重 8:很重 9:非常重 10:嚴重

(7) 別人有多常因你母語中的外地口音把你認作非本地人? **請圈出適當的級別:**

級別: 0:從不 1:差不多沒有 2:少許 3:偶爾 4:間中 5:一半的時間 6:較常 7:通常 8:時常 9:經常 10:常常

你的第二語言:__________________

以下的問題是關於你的第二語言背景及能力

(1) 請寫出當時的年齡

開始學習:	說話流利:	開始閱讀:	閱讀順暢

(2) 請寫出你於以下的語言環境的逗留時間

	年	月
以你的第二語言作通行語言的國家		
以你的第二語言作日常交流的家庭		
以你的第二語言作日常交流的學習/工作地方		

(3) 請選擇你於會話, 理解及閱讀各範疇的能力級別 (0 為不懂 10 為完全掌握)

範疇	級別	範疇	級別	範疇	級別
會話		理解		閱讀	
級別: 0: 不懂 1: 很弱 2: 弱 3: 一般 4: 介乎一般與足夠之間 5: 足夠 6: 介乎足夠與好之間 7: 好 8: 很好 9: 非常好 10: 完全掌握					

(4) 請選舉下列因素對你第二語言學習的影響級別 (0 為沒有 10 為最大)

因素	級別	因素	級別
跟朋友溝通		語言錄音帶/自我指導	
跟家人溝通		看電視	
閱讀		聽收音機	
級別: 0:沒有 1:很少 2:少許 3:一般 4:介乎一般與中等之間 5:中等 6:介乎中等與大之間 7:大 8:很大 9:非常大 10:最大			

(5) 現有的你有多常於以下情況接觸第二語言 (0 為從不 10 為常常)

情況	級別	情況	級別
跟朋友溝通		語言錄音帶/自我指導	
跟家人溝通		看電視	
閱讀		聽收音機	
級別: 0:從不 1:差不多沒有 2:少許 3:偶爾 4:間中 5:一半的時間 6:較常 7:通常 8:時常 9:經常 10:常常			

(6)你認為你的第二語言有多重的外地口音? **請圈出適當的級別:**

級別:0:沒有 1:差不多沒有 2:很少 3:少 4:有些 5:中等 6:相當 7:重 8:很重 9:非常重 10:嚴重

(7) 別人有多常因你第二語言中的外地口音把你認作非本地人? **請圈出適當的級別:**

級別: 0:從不 1:差不多沒有 2:少許 3:偶爾 4:間中 5:一半的時間 6:較常 7:通常 8:時常 9:經常 10:常常

Appendix C

Table 5a. Self-reported language profile of local EMI vs international school students (part1)

	Types of school					
	Local EMI school			International school		
language experience and history	**Range**	**Mean**	**S.D.**	**Range**	**Mean**	**S.D.**
Age (in years old)						
Began acquiring	0-7	2.8	1.6	0-7	2.5	1.7
Became fluent	2-17	10.0	4.6	3-14	8.4	3.5
Began reading	1-11	4.5	2.3	3-11	5.8	2.3
Became fluent reading	3-17	9.6	4.0	5-15	9.5	3.1
Self-reported proficiency (a)						
Reading	4-9	6.1	1.6	6-10	7.3	1.2
Understanding	3-10	6.6	1.3	6-10	7.8	1.2
Speaking	4-10	6.6	1.3	5-10	7.8	1.5

(a) 0(none) to 10 (perfect)

Appendix D

Table 5b. Self-reported language profile of local EMI vs international school students (part2)

	Local EMI school			International school		
language experience and history	**Range**	**Mean**	**S.D.**	**Range**	**Mean**	**S.D.**
Contribution to language learning (b)						
Friend	0-10	4.6	2.6	2-10	8.0	1.6
Family	0-10	3.0	3.0	0-9	4.2	2.9
Reading	4-10	8.2	1.6	3-10	7.9	2.0
Language tape	0-10	4.2	3.0	0-9	3.0	3.1
TV	1-10	6.4	2.4	1-10	6.6	2.3
Degree of language exposure (c)						
Friend	0-8	3.8	2.2	1-10	6.5	2.5
Family	0-8	1.9	2.0	0-8	2.7	2.3
Reading	3-10	7.5	2.4	0-10	7.1	2.5
Language tape	0-9	3.7	2.4	0-10	4.3	3.6
TV	2-10	5.8	2.7	2-10	6.8	2.4
Radio	0-10	2.5	2.8	0-10	3.4	3.5

(b) 0 (not a contributor) to 10 (most important contributor). (c) 0 (never) to 10 (always).

Appendix E

Table 6. RTS score for students with different age of fluent speaking in American English modules of HINT in quiet (in dBA) and averaged noisy conditions (in dB S/N)

Listening conditions	**Age of fluent speaking**					
	Age 5 or before (ECB)		**Age 6-14 (CPB)**		**Age 15 or after (APB)**	
	Mean	SD	Mean	SD	Mean	SD
4-talker babble	5.08	3.04	7.74	4.25	12.3	4.34
Café	3.0	1.22	5.87	3.72	11.1	2.99
MTR	0.53	1.53	3.33	3.72	6.98	4.41
Speech spectrum shaped noise	-0.43	0.83	2.53	2.94	7.48	5.10
Averaged Noise	2.04	1.05	4.86	3.03	9.45	3.95
Quiet	24.2	3.42	27.6	5.06	32.3	4.08