Speech audiometry with non-native English speakers: The use of digits and Cantonese words as stimuli

Audiométrie vocale chez des personnes dont la langue maternelle n'est pas l'anglais : l'utilisation de chiffres et de mots en cantonais comme stimuli

Stefka H. Marinova-Todd
Carrie K. Siu
Lorienne M. Jenstad

KEY WORDS
SRT
WRS
DIGITS MULTILINGUAL
SPEECH AUDIOMETRY
NON-NATIVE ENGLISH
CANTONESE

Stefka H. Marinova-Todd, Ed.D.
School of Audiology and Speech Sciences
University of British Columbia
2177 Wesbrook Mall
Vancouver, B.C.
Canada

Carrie K. Siu, M.Sc. Aud(C)
3740 Albert St #1104
Burnaby, B.C. V5C 5Y7
Canada

Lorienne M. Jenstad, Ph.D.
School of Audiology and Speech Sciences
University of British Columbia
2177 Wesbrook Mall
Vancouver, B.C.
Canada

Abstract

This pilot study investigated validity of English speech audiometry with non-native English speakers. Two widely used procedures in speech audiometry, the Speech Reception Threshold and the Word Recognition Score, were administered to 45 adults with English as their second language, 30 of whom were Cantonese native speakers. The effects of test stimuli (English words, English digits and Cantonese words) on the test performance were analyzed. English digit pair stimuli were found to be more accurate predictors of pure-tone average than English word stimuli for all participants, while Cantonese words elicited the lowest speech audiometric thresholds from the Cantonese-speaking participants. In terms of word recognition scores, the effect of noise was largest when testing was done in the second language. The subjects with hearing impairment were not disadvantaged when tested in their first language, Cantonese, but they had significantly lower scores when tested in their second language, English. The results from this study are of theoretical importance. In order to determine their clinical significance, more research with larger sample sizes is necessary. We conclude that clinicians should use caution when interpreting the results from a speech test when assessing non-native English-speaking clients.

Abrégé

Cette étude pilote a examiné la validité d'une audiométrie en anglais chez des personnes dont la langue maternelle n'est pas l'anglais. Un groupe de quarante-cinq adultes, pour qui l'anglais est la langue seconde et dont trente parlent le cantonais comme langue première, a passé deux tests très répandus en audiométrie vocale : le seuil d'intelligibilité et le pourcentage de reconnaissance des mots. Les effets des stimuli (mots anglais, chiffres anglais et mots cantonais) sur les résultats du test ont été analysés. Les chiffres en anglais étaient des indicateurs plus précis de la moyenne des sons purs que les mots en anglais pour tous les participants, alors que les mots en cantonais ont obtenu les seuils d'audiométrie vocale les plus bas pour les participants parlant le cantonais. En ce qui concerne le pourcentage de reconnaissance des mots, les répercussions du bruit étaient plus grandes lorsque le test était effectué dans la langue seconde. Les sujets souffrant de troubles auditifs n'étaient pas désavantagés lorsque le test était effectué dans leur langue première, le cantonais, mais ils ont obtenu des résultats significativement plus bas lorsque testés dans leur langue seconde, l'anglais. Les résultats de cette étude ont une importance théorique. Afin de déterminer leur signification clinique, il est nécessaire d'effectuer davantage de recherches sur des échantillons plus grands. Nous avons conclu que les cliniciens devraient faire preuve de prudence lorsqu'ils interprètent les résultats d'un test oral effectué chez des patients dont la langue maternelle n'est pas l'anglais.

A survey conducted by the Canadian Association of Speech-Language Pathologists and Audiologists in 2003 showed that among its 423 registered audiologists, 93% spoke English as their first language and the rest spoke French as their first language. However, the 2006 Census conducted by Statistics Canada revealed 19.7% of Canadians spoke neither English nor French as their first language. This percentage is much higher in some of the major cities. For example, 41.7% of the citizens in the Greater Vancouver metropolitan area of British Columbia report neither English or French as a first language. Eighteen percent of the population in this metropolitan area reported that Chinese was their mother tongue (Statistics Canada, 2006). The under-representation of language minority members in the Audiology profession is similarly seen in the United States, where only 7% of certified Audiologists identified themselves as belonging to racial minority groups (American Speech, Language and Hearing Association, 2009). These statistics demonstrate the need for a linguistically and culturally sensitive approach towards conducting speech audiometry with non-native English speakers. When hearing tests using English speech stimuli are administered to people for whom English is not their first language, knowledge and proficency of English, as well as hearing sensitivity, may contribute significantly to test performance.

SPEECH AUDIOMETRY WITH NON-NATIVE ENGLISH SPEAKERS

Beverley-Ducker (2003) reported an increasing need to prepare for, and respond to, racial, ethnic and linguistic diversity of current and future caseloads as well as a need to develop culturally and linguistically sensitive assessment tools. She also pointed out a need to conduct research on the reliability of speech audiometric test results with non-native English speakers. Although most clinicians are aware of the need for more linguistically sensitive assessment tools, they still use English speech tests for non-English-speaking clients because of their availability, longevity, research support, and most importantly, compatibility with their own language (Ramkissoon & Khan, 2003). In some cases, audiologists who use alternative speech audiometry tests use subsets of the English standardized word lists. However, research showed that using a smaller list than the standardized list resulted in better Speech Reception Thresholds (SRTs) due to familiarization with test stimuli, thus sacrificing test validity (Ramkissoon, Proctor, Lansing, & Bilger, 2002). Another alternative is to administer speech audiometry in the client's native language. Speech tests have been developed and standardized for *monolingual* speakers of languages other than English (e.g., *Arabic*: Ashoor & Prochazka, 1982; *Canadian French*: Vaillancourt, Laroche, Mayer, Basque, Nali, Eriks-Brophy, Soli, & Giguère, 2005; *Cantonese*: Wong & Soli, 2005; *Danish*: Wagener, Josvassen, & Ardenkjoer, 2003; *Mandarin*: Nissen, Harris, & Slade 2007; *Russian*: Harris, Nissen, Pola, McPherson, Tavartkiladze, & Eggett 2007; *Spanish*: Ferrer, 1960; Zubic, Irizarry, Rosen, Feudo, Kelly, & Strome, 1983; and *Swedish*: Hällgren, Larsby, & Arlinger, 2006.), but it is not clear whether these tests are appropriate for bilingual speakers. In the field of bilingualism and second language acquisition, it has been established that bilingual individuals perform differently from monolinguals on a variety of tasks, including both language-based and non-language-based tasks (Michael & Gollan, 2005). It is unknown how bilinguals perform on speech tests that have been developed and standardized on monolingual populations alone.

Research findings suggest that when the clinician does not speak the client's first language, it may be more valid to use digit pairs in SRT measures than spondees. Ramkissoon and colleagues (2002) compared the SRT of native English speakers and non-native speakers using digit pairs versus standardized spondees as stimuli. They assessed the accuracy of the two stimuli by comparing the SRT obtained with the pure tone average (PTA), and found that compared with compound words, digit pairs more accurately measured the hearing threshold for speech of non-native English speakers.

THE CURRENT STUDY

The present pilot study aimed to expand upon previous research on issues relating to speech audiometry and non-native English speakers by exploring the most appropriate auditory stimuli for accurate measurement of SRT and Word Recognition Scores (WRSs) for this group. In the first part of the study, we aimed to replicate Ramkissoon et al.'s (2002) study, which had the goal of determining whether digit pairs or spondees were more accurate indicators of hearing thresholds for non-native English speakers. In addition, the present study aimed to determine which speech audiometry test stimuli (i.e., English spondees, English digits or Cantonese spondees) led to the most accurate measure of hearing sensitivity in a Cantonese-speaking group. The second part investigated Cantonese speakers' word recognition performance in quiet and noise using Cantonese versus English stimuli.

The present study had the following main research question: Is there a test stimulus effect on performance in speech audiometry for non-native English speakers? Additional specific questions addressed were:

1. Does SRT differ depending on stimuli used

(English spondees vs. digit pairs vs. first language spondees)?

2. Do WRS in quiet and in noise differ depending on language of stimuli used (first language or second language)?

METHOD

Participants

Participants were recruited by word-of-mouth, by email, and by advertisements posted at local university campuses and at various libraries and community centers across a major metropolitan city in Canada. A total of 45 non-native English speakers participated (see Table 1). Among them, 30 spoke Cantonese as their native language. The native languages of the remaining 15 subjects were Tagalog, Japanese, German, Bulgarian, Punjabi, Mandarin, and French. The subjects' ages ranged from 19 to 69 years, with a mean age of 48 years for the Cantonese-speaking group and 37 years for the group who spoke other languages. The Cantonese speakers were evenly divided in terms of gender (15 males; 15 females), as were the speakers of other languages (7 males; 8 females). Sixteen out of the 45 participants (2 in the non-Cantonese group and 14 in the Cantonese group) had a hearing loss: Eight subjects had hearing loss in the high frequencies (2000-4000 Hz), 1 subject had hearing loss in the low frequencies (250-1500Hz), and 7 subjects had hearing loss in both high and low frequencies. Normal hearing was considered pure tone thresholds of 25 dB HL or better from 250 to 4000 Hz in both ears.

and, when paired with another digit, would result in digit pairs with more than two syllables. We obtained 56 digit pairs with no item containing a repeated number. To match the number of stimuli for the CID-spondees, 18 pairs were randomly selected from these 56 pairs for use in the study.

Stimuli for the WRS were words from the NU-6 List 3A. This list, among the six lists developed by Tillman and Carhart (1966), consisted of 50 phonemically balanced monosyllabic words. For this study, two 25-word lists - the first and last 25 words of NU-6 List 3A - were randomly used during testing. Half-lists (25 words), instead of full lists of 50 words, were used because a survey conducted in 2000 indicated that this was the list of choice by most Canadian audiologists (DeBow & Green, 2000). Therefore, half-lists were used to increase the efficiency and clinical applicability of this study.

Stimuli for the Cantonese SRT and WRS comprised lists of Cantonese spondees and monosyllabic words. At the time of the present study, standardized Cantonese word lists were not available. The stimuli in the present study were developed by Cantonese-speaking clinical audiologists and were discussed with three native Cantonese speakers who had academic training in linguistics. Eventually, these lists were deemed to adequately represent all Cantonese speech sounds in a phonemically-balanced manner. The lists consisted of common words that would be familiar to adult participants who are native speakers of Cantonese.

Table 1
Background characteristics for all subjects (N=45).

	Cantonese Mean (SD)	Non-Cantonese Mean (SD)
N	30	15
PTA (dB HL)	12.75 (15.92)	6.22 (10.75)
Length of Residence in L2 Country (yrs)	12.53 (4.31)	11.87 (13.05)
Age of first exposure to L2 (yrs)	8.5 (2.98)	11.33 (8.30)
Years of L2 instruction	10.87 (4.69)	9.33 (4.64)
Age at time of testing	48.17 (15.24)	37 (12.60)

Stimuli

Stimuli for the English SRT were the 18 spondees of the American Speech and Hearing Association half list A (American Speech and Hearing Association, 1988), adapted from the CID W-1 word list. Stimuli for the digit SRT test were compiled in the same way as the study conducted by Ramkissoon et al. (2002). Two individual numbers from “1” to “9”, excluding “7”, were paired. The number “7” was excluded because it has two syllables

Procedure

Bilateral pure tone air conduction thresholds at 500, 1000, 2000, and 4000 Hz and SRTs were measured using standard clinical procedures (American Speech and Hearing Association, 1978, 1979, 1988). Pure-tone averages were calculated from thresholds at 500, 1000, and 2000 Hz, using the Fletcher 2-frequency average (Fletcher, 1950) where appropriate (i.e., where adjacent thresholds differed by 20 dB or more). For testing word recognition in quiet, subjects were presented with 25 words from NU-6 List 3A to both ears simultaneously at a supra-threshold level, i.e. the higher of 45 dB HL or the Most Comfortable Level. Participants were instructed to repeat aloud the words heard and the percentage of correctly repeated words was calculated.

Word recognition in noise testing was performed binaurally via two standard CD players, with the recorded NU-6 words routed through one CD player and the Auditec cafeteria noise (Auditec of St. Louis, St. Louis, MO) routed through the second player. The twenty-five NU-6 List 3A words along with background cafeteria noise were presented diotically via supra-aural earphones (TDH 50-P, Telephonics, Farmingdale, NY). The two half-lists were randomized depending on whether they were tested in quiet or noise for each listener. The words were presented at the same intensity as when testing in quiet, while the noise was presented at an intensity of 5 dB lower than the presentation level of the words (signal-to-noise ratio of +5 dB).

For the Cantonese-speaking participants, in addition to word recognition in English, word recognition in Cantonese was tested using the same procedure as in English. A 25-word list was presented at the same intensity as described above in quiet and in noise. The noise used was the same track of cafeteria noise as used in English testing, presented at a signal-to-noise level of +5 dB. Two recorded Cantonese word lists were used and their order of presentation was randomized among participants. Half of the subjects heard the stimuli in English first, and the other half heard the stimuli in Cantonese first. All Cantonese stimuli were spoken by a Cantonese-English bilingual female speaker and were digitally recorded with computer software and equated for peak intensity.

All testing was performed using a diagnostic audiometer (Grason-Stadler, GSI 61, Eden Prairie, MN) in a sound-treated booth where the ambient noise met the ANSI standard for audiometric testing (ANSI, 1979). At the end of testing, each participant was briefed on the test results.

Results

In a first step of the analysis, we confirmed for each of the stimulus sets that measures from both ears of listeners were highly correlated and not significantly different. Therefore, the average of scores from the left and right ears were used as the measurement. The effects of hearing loss on SRT and WRS were also analyzed.

SRT Results

A mixed-design ANOVA was used to investigate any differences in SRT performance between the Cantonese-speaking group and the non-Cantonese-speaking group, and between the hearing-impaired and normal-hearing groups. The data were analyzed using a 2 (language) x 2 (hearing status) x 2 (stimulus type) repeated-measures ANOVA, where language (Cantonese and non-Cantonese speakers) and hearing status (normal hearing and hearing impaired) were the between-subject factors, and the stimulus type (CID spondees vs. digits) was the within-subject factor. There was a significant main effect of hearing status (F (1, 41) = 54.89, p <0.0001), where hearing-impaired individuals had higher SRTs than normal-hearing individuals, a significant main effect of language (F (1, 41) = 7.16, p = 0.01), a significant main effect of stimulus type (F (1, 41) = 40.55, p < 0.0001), such that subjects had a significantly lower mean SRT when the stimuli were digit pairs than when they were English spondees, and a significant interaction between hearing status, language and hearing test (F (1,41) = 7.21, p = 0.01). Subsequent analysis revealed that in the normal-hearing group there was only a significant main effect of stimulus type (F (1, 27) = 11.49, p = 0.002) indicating that both Cantonese and non-Cantonese-speaking subjects had lower (better) thresholds for digits than spondees; however, the main effect of language group (F (1,27) = 0.01, p = 0.93) and the interaction between language group and stimulus type (F (1, 27) = 1.36, p = 0.25) were not significant. Similarly, in the hearing-impaired group there was a significant main effect of stimulus type (F (1,14) = 17.83, p = 0.0009) but no significant main effect of language (F (1,14) = 3.36, p = 0.09). However, the interaction between stimulus type and language was significant (F (1, 14) = 5.09, p = 0.03) and revealed that the difference between the digits and spondee scores was greater among the non-Cantonese speakers. Due to the very small sample size of the non-Cantonese group, caution needs to be applied when interpreting the results of the hearing-impaired non-Cantonese group. Results are displayed in Figure 1.

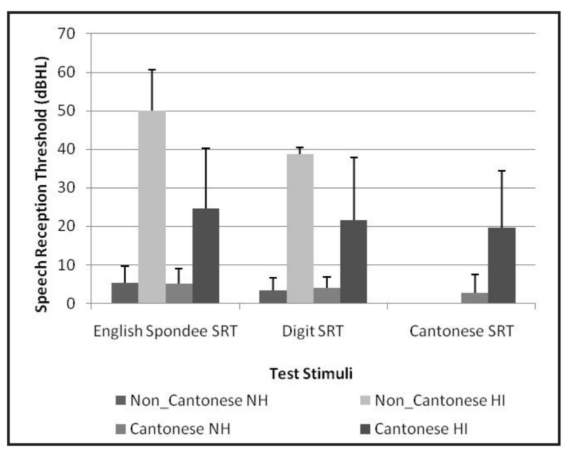

Figure 1: Comparison of the mean SRT between the normal hearing group and the hearing-impaired group of non-Cantonese (N = 15) and Cantonese-speaking subjects (N=30) (NH = normal hearing; HI = hearing impaired).

To determine accuracy of the SRT measure, SRT values were compared with pure tone averages. Paired t-tests revealed a significant difference between PTA (*Mean* = 10.57, *SD* = 14.67) and CID-SRT (*Mean* = 13.22, *SD* = 16.77), *t* (89) = -3.87, *p* = 0.0002. No significant difference was found between PTA and Digit-SRT (*Mean* = 10.89, *SD* = 15.39), *t* (89) = - 0.58, *p* = 0.56. Correlational analyses revealed a high correlation between both Digit-SRT and PTA (*r* = 0.94, *p* < 0.0001) and between CID-SRT and PTA (*r* = 0.92, *p* < 0.0001). Therefore, digit pairs were found to be accurate in predicting the hearing threshold for speech for non-native speakers and provide a better alternative to the CID W-1 spondees. Moreover, for the group on average, the difference between PTA and SRT was less than 6 dB for both stimulus types, which is considered to be a good agreement (Brandy, 2002).

COMPARISONS BETWEEN ENGLISH AND CANTONESE TEST MATERIALS

The largest group of subjects was from Cantonese background, and we examined their performance on the English and Cantonese SRT. The data were analyzed using a 2 (hearing status) x 3 (stimulus type) repeated-measures ANOVA, where hearing status (normal hearing and hearing impaired) was the between-subjects factor, and the stimulus type (English spondees vs. digits vs. Cantonese spondees) was the within-subject factor. The descriptive statistics on the English and Cantonese tests are presented in Table 2. The univariate tests of repeated measures revealed a significant main effect of stimulus type (*F* (2,56) = 21.29, *p* < 0.0001), a significant main effect of hearing status (*F* (1, 28) = 20.60, *p* <0.0001), and a significant interaction between hearing status and stimulus type (*F* (2,56) = 3.51, *p* = 0.04). Subsequent analyses revealed that it was only in the hearing-impaired group that there was a significant main effect of stimulus type (*F* (2, 13) = 21.60, *p* < 0.0001), and an examination of Figure 1 indicated that the hearing-impaired subjects had significantly lower Cantonese SRT scores than digits (*p* = 0.009), and their Cantonese and digit SRT scores were significantly lower than their English SRT scores (*p* = 0.0001 and *p* = 0.003, respectively).

When compared with the mean pure-tone average (*Mean* =12.75, *SD* = 15.92), a significant difference was found between PTA and English SRT (*Mean* = 14.17, *SD* = 17.03), *t* (59) = -2.14, *p* = 0.0369, and between PTA and Chinese SRT (*Mean* = 10.67; *SD* = 16.53), (*t* (59) = 3.16, *p* = 0.0025), while no significant difference was found between PTA and Digit SRT (*Mean* = 12.25; *SD* = 16.45), *t* (59)= 0.75, *p* =0.4566. Correlation analyses revealed strong positive relationships between PTA and English spondee SRT (*r* = 0.953, *p* <0.0001), PTA and Digit SRT (*r* = 0.950, *p* < 0.0001), and PTA and Cantonese SRT (*r* = 0.951, *p* < 0.0001). Therefore, for the Cantonese-speaking participants, digit pairs resulted in more accurate measures of hearing sensitivity than either English or Cantonese stimuli. For the group on average, the difference between PTA and SRT was less than 6 dB for both stimulus types, which is considered to be a good agreement (Brandy, 2002).

PERFORMANCE ON WRS

WRS was conducted binaurally on all participants but only the Cantonese speakers were tested with the Cantonese stimuli. Because a main goal of the study was to compare performance for stimuli in the native language to performance for stimuli in the non-native language, only results from the 30 Cantonese-speaking participants are presented here. The descriptive statistics on word recognition are presented in Table 2, with the data in rationalized arcsine units (RAUs; Studebaker, 1985). The data were analyzed using a 2 (hearing status) x 2 (noise) x 2 (stimulus language) repeated-measures ANOVA, where hearing status (normal hearing and hearing impaired) was the between-subject factor, and noise (noise vs. quiet) and stimulus language (English vs. Cantonese words) were the within-subject factors. There was a significant main effect of hearing status (*F* (1, 28) = 7.61, *p* = 0.01), a significant main effect of noise (*F* (1, 28) = 57.65, *p* < 0.0001), and a significant main effect of stimulus language (*F* (1, 28) = 73.24, *p* < 0.0001). While the interaction among all three factors was not significant (*F* (1, 28) = 0.78, *p* = 0.38), the interactions between stimulus language and hearing status

Table 2
Word recognition scores (WRS) in RAUs for different conditions for the Cantonese-speaking subjects only (N = 30).

	English Quiet Mean (SD)	English Noise Mean (SD)	Cantonese Quiet Mean (SD)	Cantonese Noise Mean (SD)
Normal Hearing (N = 16)	95.00 (5.16)	88.00 (8.39)	99.25 (1.61)	96.00 (4.38)
Hearing Impaired (N = 14)	85.79 (13.37)	73.43 (16.05)	96.86 (6.11)	93.43 (7.12)

(p (1, 28) = 9.29, p = 0.005), and stimulus language and noise (F (1, 28) = 6.02, p = 0.02) were both statistically significant. The two interaction effects are displayed on Figure 2 and Figure 3 respectively.

Upon closer examination of Figure 2 and the simple main effects it became apparent that the word recognition scores in English were significantly lower than the word recognition scores in Cantonese for both the normal-hearing (F (1, 15) = 23.14, $p < 0.0001$) and hearing-impaired groups (F (1, 13) = 47.02, $p < 0.0001$). On the other hand, while the English scores of the hearing-impaired group are significantly lower than those of the normal-hearing group (F (1, 28) = 10.19, p = 0.003), there was no significant difference between the groups when tested in Cantonese (F (1, 28) = 1.82, p = 0.19). In other words, the effect of hearing impairment was greater when tested in the second language than in the native language.

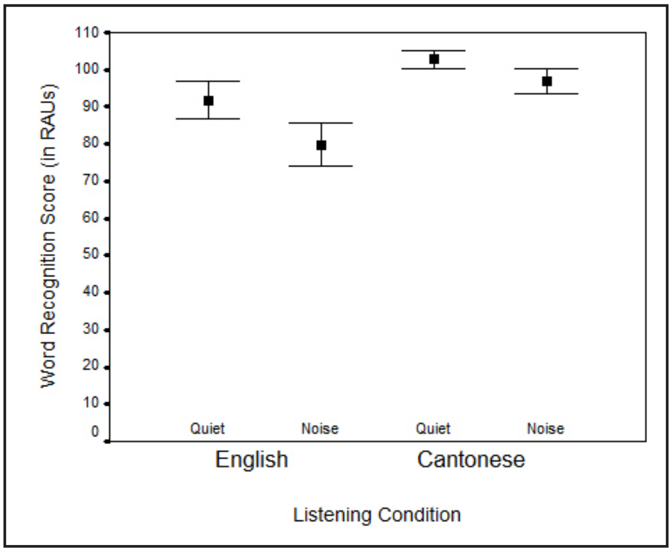

Figure 2: Interaction between the Noise and Language variables, collapsed across hearing status for the Cantonese-speaking subjects (N = 30).

Upon closer examination of Figure 3 and the simple main effects, it was found that the word recognition scores were lower in English than in Cantonese when tested both in quiet (F (1, 29) = 28.96, $p < 0.0001$) and in noise (F (1, 29) = 45.35, $p < 0.0001$). Moreover, subjects' WRSs were lower when tested in noise than when tested in quiet in both English (F (1, 29) = 34.61, $p < 0.0001$) and Cantonese (F (1, 29) = 16.32, $p < 0.0001$). However, the effect of noise was greater when the subjects were tested in their second language, English.

Overall, for this subgroup of Cantonese speakers, the mean supra-threshold word recognition was significantly better when stimuli were presented in Cantonese than when they were presented in English. This finding applied to testing in quiet and in noise, and to both normal-hearing and hearing-impaired listeners.

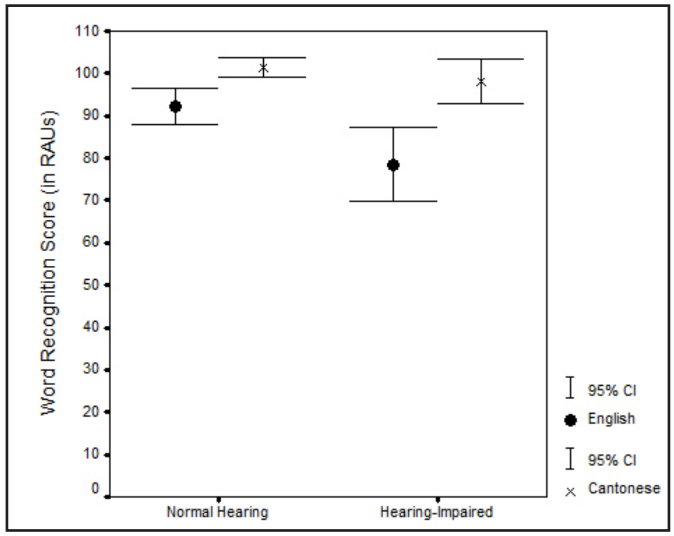

Figure 3: Interaction between Language and Hearing status, collapsed across noise for the Cantonese-speaking subjects (N = 30).

DISCUSSION

The present pilot study confirmed Ramkissoon and colleagues' (2002) finding that compared with CID spondees, digit pairs elicited more accurate SRTs that closely approximated the PTA. Similarly, we conclude that compared to CID spondees, digit pairs should facilitate more accurate SRT testing for non-native speakers of English. In addition, results from the Cantonese participants suggested that PTA might not accurately reflect hearing sensitivity for speech in all languages. The standard calculation for PTA was derived from the acoustic spectrum of English speech sounds, in which the majority of sounds lies within 500-2000 Hz. The lower threshold obtained from using Cantonese spondees compared to the PTA suggests that the frequencies 500-2000 Hz may not be an accurate representation of Cantonese speech sounds. The frequency-importance function for Cantonese sentences shows that low-frequency information is more important for sentence recognition in Cantonese than in English (Wong, Ho, Chua, & Soli, 2007). The authors of that study suggested that the increased low-frequency importance was in part due to the tonal nature of the Cantonese language. It can be speculated that similar differences in frequency importance might also apply to the spondaic materials used in the current study.

A significant effect due to stimulus language was also found in the WRS results. Both in quiet and in noise, performance of the Cantonese-speaking participants for supra-threshold word recognition was significantly better when stimuli were in their first language than in English. Moreover, the effect of noise was greater when the stimuli were presented in the second language than in the native language of the participants. This effect is consistent with previous research, in which a decrease in word recognition performance in noise in a non-native language has been documented (von Hapsburg & Pena, 2002). Most of the past studies compared non-native speakers' performance with that of native speakers. Despite effort in matching individual participants' characteristics between the native and non-native groups, inter-subject variability, nevertheless, could not be entirely eliminated. The present study compared performance between a native and a non-native language within subjects, thereby eliminating the effect of inter-subject variability on the results.

We also found that for both normal-hearing and hearing-impaired groups of Cantonese listeners, noise had little effect on WRS when stimuli were in their native language. In an effort to keep experimental conditions consistent, the same cafeteria noise was used in the measurement of both English and Cantonese WRS. Due to the fact that the background speech in the cafeteria noise was in English, a release of masking effect might have resulted during Cantonese WRS measurement because the signal and noise were in different languages. As quantified by the frequency-importance function, the important acoustic cues within Cantonese speech span a frequency range different from English speech, possibly enabling a release of masking when the competing background noise was in English while the signal was in Cantonese. Generalizing our results beyond the lab, it could be hypothesized that Cantonese speakers in English-speaking societies may be less affected by background English speech, and that Cantonese hearing-impaired people may experience less social impairment than their English-speaking counterparts.

IMPLICATIONS

The major findings of the present study are 1) for non-native speakers of English, digit pairs as SRT stimuli more accurately measured hearing threshold for English speech than CID W-1 spondees; 2) for the Cantonese participants, digit pairs also more accurately measured hearing threshold for English speech than either English or Cantonese spondees, however, Cantonese spondees elicited a better hearing threshold than English stimuli; 3) for the Cantonese participants, performance for monosyllabic word recognition was significantly better when stimuli were in Cantonese than when they were in English; this effect existed across testing conditions (quiet and noise) and despite the presence of hearing loss; and 4) for the Cantonese participants, the presence of hearing loss affected word recognition in English significantly more than word recognition in Cantonese.

Of importance for clinicians, the present study found the language of test stimuli to significantly affect test accuracy in speech audiometry for non-native English speakers. Although the average discrepancy between SRT and PTA was within 6 dB for both stimulus types, which is considered "good" agreement (Brandy, 2002), the individual data show that for the CID spondees, 29 of 90 ears were not in good agreement (i.e., more than 6 dB discrepancy), and for the digit spondees, only 17 of 90 ears were not in good agreement. The clinical importance of this needs to be determined via larger and more varied sample sizes. As the consistency between SRT and PTA is an important indicator of pseudohypacusis, and testing in the non-native language may result in discrepancy between SRT and PTA, pseudohypacusis may be misdiagnosed when insufficient knowledge of the native language may be the true cause of SRT-PTA discrepancy. Therefore, clinicians serving multicultural clients should be aware that it may not be only hearing sensitivity that they are measuring, but also their clients' language ability.

The interesting supplemental finding that hearing-impaired listeners performed differently from normal hearing listeners only in their non-native language (English) has significant clinical implications. As most clients at an Audiology clinic have a certain degree of hearing loss, extra caution should be taken in applying and interpreting English WRS for non-native speakers of English because a hearing loss increases the confounding effect of language on their performance in English WRS. This evidence strongly supports the use of speech recognition tests in the client's native language. Many versions of the Hearing In Noise Test are being developed and validated in languages other than English (e.g., Cantonese; Wong and Soli 2005). The clinician should be aware of the main language groups in their community and, if appropriate test materials have been developed for that language, ensure that these speech tests are available in their clinic. However, it is important that these tests are administered by native speakers of the language whenever possible because the use of such tests may increase the possibility of "auditor errors" (e.g., Nelson & Chaiklin, 1970), which could presumably increase when administered by non-native speakers of the language.

FUTURE DIRECTIONS

As this was a pilot study, we included a small group of hearing-impaired subjects to assure applicability and generalization of results to clinical populations. Due to the small sample size, however, all hearing-impaired participants were categorized into one group for comparison to the normal hearing group. In future studies, the use of a larger number of hearing-impaired participants is recommended in order to define the relationship between hearing loss and the effects noted in the current study. We chose to include a clinician-developed WRS test in Cantonese that was the only option available to us at the time. In future studies, researchers should aim to develop standardize speech tests in Cantonese with known psychometric properties. Moreover, it would be informative to include an English-speaking comparison group as a control for the English speech tests, as well as to provide a context for the interpretation of the results.

REFERENCES

American National Standards Institute (1979). *American National Standard Specification for Audiometers*. New York: American National Standards Institute, Inc.

American Speech, Language and Hearing Association (2009). *Summary Counts by Ethnicity and Race*. Retrieved from http://www.asha.org/uploadedFiles/2009MemberCounts.pdf

American Speech and Hearing Association (1988). *Determining the Threshold Level for Speech. [Guidelines]* Retrieved from http://www.asha.org/policy

American Speech and Hearing Association (1979). Guidelines for determining the threshold level for speech. *ASHA, 21, 353–356.*

American Speech and Hearing Association (1978). Guidelines for manual pure tone speech audiometry. *ASHA, 20, 297–301.*

Ashoor, A.A., & Prochazka Jr., T. (1982). Saudi Arabic speech audiometry. *Audiology, 21*, 493–508.

Beverly-Ducker, K. (2003). Multicultural issues in Audiology. *ASHA Division 9 Newsletter, 13*, 12–15. doi:10.1044/hhdc13.1.12

Brandy, W. (2002). Speech audiometry. In J. Katz (Ed.), *Handbook of Clinical Audiology*, 5th ed (pp. 96–110). Baltimore, MD: Lippincott Williams and Wilkins.

DeBow, A., & Green, W.B. (2000). A survey of Canadian audiological practices: Pure tone and speech audiometry. *Journal of Speech-Language Pathology and Audiology, 24*, 153–161.

Ferrer, O. (1960). Speech audiometry: A discrimination test for Spanish language. *Laryngoscope, 70*, 1541–1551.

Fletcher, H. (1950). A method of calculating hearing loss for speech from an audiogram. *Acta Oto-laryngologica Supplementum, 90*, 26–37.

Hällgren, M., Larsby, B., & Arlinger, S. (2006). A Swedish version of the Hearing In Noise Test (HINT) for measurement of speech recognition. *International Journal of Audiology, 45*, 227–237.

Harris, R.W., Nissen, S.L., Pola, M.G., McPherson, D.L., Tavartkiladze. G.A., & Eggett, D.L. (2007). Psychometrically equivalent Russian speech audiometry materials by male and female talkers. *International Journal of Audiology, 46*, 47–66.

Michael, E., & Gollan, T.H. (2005). Being and becoming bilingual: Individual differences and consequences for language production. In J.F. Kroll & A.M.B. de Groot (Eds.), *The handbook of bilingualism: Psycholinguistic approaches* (pp. 389–407). New York: Oxford University Press.

Nelson D.A., & Chaiklin J.B. (1970). Writedown versus talkback scoring and scoring bias in speech discrimination testing. *Journal of Speech and Hearing Research, 13*, 645–654.

Nissen, S.L., Harris R.W., & Slade, K.B. (2007). Development of speech reception threshold materials for speakers of Taiwan Mandarin. *International Journal of Audiology, 46*, 449–458.

Ramkissoon, I., & Khan, F. (2003). Serving multilingual clients with hearing loss: How linguistic diversity affects audiologic management. *ASHA Leader, 8* (3), 1, 10–11, 27. Retrieved from http://www.asha.org/Publications/leader/2003/030218/030218a.htm

Ramkissoon, I., Proctor, A., Lansing, C.R., & Bilger, R.C. (2002). Digit speech recognition thresholds for non-native speakers of English. *American Journal of Audiology, 11*, 23–28.

Statistics Canada (2006). Population by *Mother Tongue: 2006 Census*. Retrieved from http://www40.statcan.gc.ca/l01/cst01/demo12g-eng.htm

Studebaker, G. A. (1985). A “rationalized” arcsine transform. *Journal of Speech and Hearing Research, 28*, 455–462.

Vaillancourt, V., Laroche, C., Mayer, C., Basque, C., Nali, M., Eriks-Brophy, A., Soli, S.D., & Giguère, C. (2005). Adaptation of the HINT (hearing in noise test) for adult Canadian Francophone populations. *International Journal of Audiology, 44*, 358–69.

Von Hapsburg, D., & Pena, E.D. (2002). Understanding bilingualism and its impact on speech audiometry. *Journal of Speech, Language and Hearing Research, 45*, 202–213.

Wagener, K., Josvassen, J.L., & Ardenkjær, R. (2003). Design, optimization and evaluation of a Danish sentence test in noise. *International Journal of Audiology, 42*, 10–17.

Wong, L.L., Ho, A.H., Chua, E.W., & Soli, S.D. (2007). Development of the Cantonese speech intelligibility index. *Journal of the Acoustical Society of America, 121*, 2350–2361.

Wong, L.L., & Soli, S.D. (2005). Development of the Cantonese Hearing In Noise Test (CHINT). *Ear and Hearing, 26*, 276–289.

Zubick, H.H., Irizarry, L.M., Rosen, L., Feudo, P., Kelly, J.H., & Strome, M. (1983). Development of speech-audiometric materials for native Spanish-speaking adults. *Audiology, 22*, 88–102.

AUTHOR'S NOTE

Correspondence should be sent to Stefka H. Marinova-Todd, Ed.D., School of Audiology and Speech Sciences, University of British Columbia, 2177 Wesbrook MallVancouver, B.C., V6T 1Z3, Canada. E-mail: stefka@audiospeech.ubc.ca

Received date : February 01, 2010

Accepted date : August 10, 2010