EXAMINATION OF A PERCEPTUAL NON-NATIVE SPEECH CONTRAST: PHARYNGEALIZED/NON-PHARYNGEALIZED DISCRIMINATON BY FRENCH-SPEAKING ADULTS

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ABSTRACT

This study investigates the discrimination of a synthesized non-pharyngealized/pharyngealized place-of-articulation contrast in Arabic [si]-[sˤi], presented to Arabic-speaking subjects and French-speaking subjects. An identification task showed group differences in the location of the category boundary, reflecting language-specific experience. An AX discrimination task revealed cross-language differences in the phonemic status of the contrast and that levels of discrimination performance were strongly associated with their assimilation patterns.

1. INTRODUCTION

Cross-language research suggests that young infants can discriminate nearly every speech sound contrast on which they have been tested, including those that are not used contrastively in their language-learning environment. This has been shown in the case of both naturally record [1,2,3] and computer synthesized [4] speech syllables. in contrast to this high level of infant ability, older children and adults have difficulty identifying or discriminating non-native contrasts such as the Czech retroflex vs. palatal fricatives [1], Thai voiced vs. voiceless unaspirated stops [5], Hindi dental vs. retroflex stops, and Salish velar vs. uvular ejectives [6,7,8]. However, this perceptual difficulty appears to be neither universal or immutable. Discrimination of non-native contrasts that are initially difficult for adults can sometimes be improved rapidly through laboratory training [9], while others are resistant to change [10]. Some non-native contrasts are relatively easy to discriminate even without prior exposure or training [8]. Other contrasts are distinguisgable when listening conditions minimize memory demands or phonemic categorization [11]. Perceptual difficulties with particular contrasts also vary depending on syllable position and phonetic context [12].
According to Best' Perceptual Assimilation Model (PAM) [12], this perceptual difficulty may be explained by differences in how the non-native phones are perceptually assimilated into native phoneme categories. That is. the non-native phones are perceived in terms of their similarities and dissimilarities to native phonemes. Best suggests four possible perceptual assimilation patterns and the discrimination levels predicted for each: a) "Single-category" assimilation: the contrasting phones are assimilated as variants of a single native category. Discrimination is expected to be difficult for adults. b) "Opposing-category" assimilation: the phones are assimilated as the opposing members of a native phonological contrast, and discrimination is expected to be excellent. c) "Non-assimilation": both members are phonetically dissimilar from any native categories. Discrimination is expected to be good to very good. d) "Category-goodness difference" assimilation: one member is better assimilated to a native category (more similar phonetically) than the other. Discrimination is expected to be moderate to very good, depending on the magnitude of difference in category goodness for each of the non-native sounds.
This study focuses on the last assimilation pattern by testing discrimination of a synthesized non-pharyngealized/pharyngealized place-of-articulation contrast in Arabic /si/-/sˤi/, presented to Arabic-speaking subjects and French-speaking subjects. We assessed whether French subjects would show moderate to very good discrimination performance for a non-native contrast, the phonetic characteristics of the pharyngealized member [sˤ] are highly dissimilar from any native category, and that therefore are unlikely to be assimilated. In contrast, the non-pharyngealized member [s] might be assimilated as a "better" exemplar of french [s].
In Arabic a pharyngealised consonant has in addition to a primary articulation (dental/alveaolar contact), which they share with a non-phayngealised consonant, a secondary articulation (backing of the tongue towards the pharyngeal wall). The acoustic consequences of this double articulation is a considerable lowering of F2 and slight raising of F1 in vowels adjacent to pharyngealised consonant.

2. METHOD

2.1. Stimulus materials

A synthesized [si]-[s$^{\text{ʕ}}$i] series generated by a software parallel synthesizer [13] were used. Synthesis parameters for series endpoints [si]-[s$^{\text{ʕ}}$i] were derived from natural utterances by a native male speaker of Arabic.
Since the F2 onset frequency is a sufficient minimal cue for the perception of a phrayngealized/non-pharyngealized, the continuum was constructed by systematically varying the onset frequency in 12 steps of 100 Hz for F2.. Figure 1 provides a schematic representation of the stimuli. All stimuli were equated for overall duration (300ms) and contained the same F0.

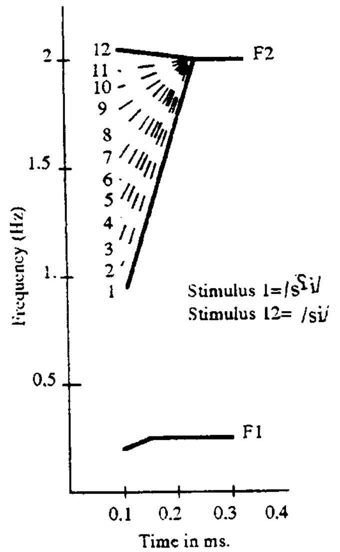

Figure1: Schematic spectrogram representations of the 12 stimuli in the synthetic /si-s$^{\text{ʕ}}$i/ series. References stimuli are presented by solid lines.

2.2. Subjects

The Arabic group (AG) was comprised of 10 native speakers of moroccan Arabic. The French group (FG) was also comprised of 10 native speakers of french, having no experience with Arabic language.

2.3. Procedure

All subjects took part in two tests:
1- A forced-choice identification that contained 5 repetitions of the 12 stimuli, presented singly and randomized within each block of 12 trials. Intertrial intervals (ITIs) were 2,5 seconds, and interblock intervals (IBIs) were 4 sec. Arabic subjects were asked to write "S" or "S$^{\text{ʕ}}$" on each trial. French subjects were asked to write "S" or "0" to design "S$^{\text{ʕ}}$".

2- An AX discrimination that contained 5 repetitions of each of the two AX orders for the ten possible pairings of stimuli that differed by 2 steps along the continuum.Trials occurred in blocks of 20 (Two orders X 10 AX pairings), and were randomized within blocks. Interstimulus intervals (ISIs) were 1 second, ITIs were 3 sec, and IBIs 6 sec.

3. RESULTS

3.1. Identification test

Figure 2 and 3 present the pooled identification functions for the AG and FG on the [s-s$^{\text{ʕ}}$] continuum, respectively.

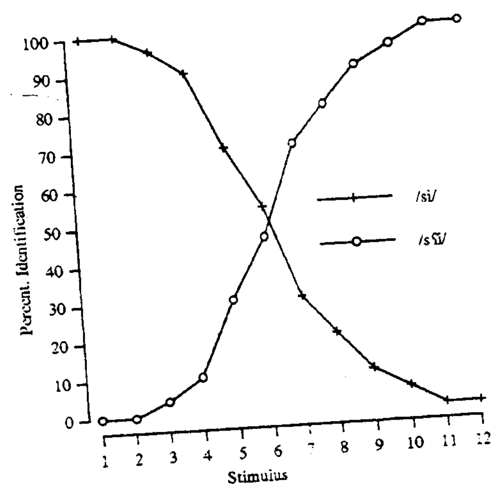

Figure2: Average identification functions for the Arabic group (AG) on the /s-s$^{\text{ʕ}}$/ series.

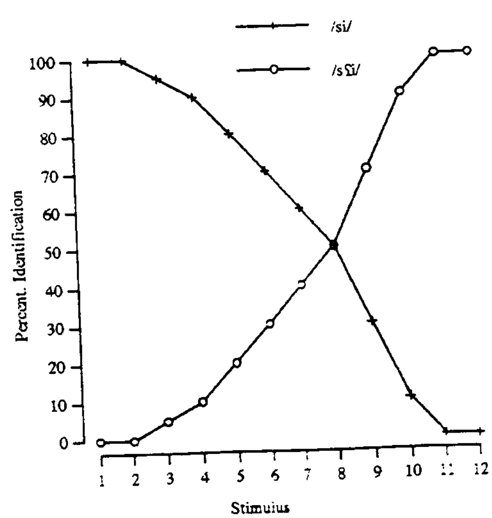

Figure3: Average identification functions for the French group (FG) on the /s-s$^{\text{ʕ}}$/ series.

AG labeled [s-sˤ] categorically with a sharp category boundary near stimulus 6, and consistent labeling of within-category stimuli. FG showed less consistency in labeling within-category stimuli and was markedly different from that of AG. Category boundaries were evaluated by interpolating the stimulus number at the 50% crossover. The boundary is at 1450.Hz (near stimulus 6) for the AG, and at 1650.Hz (at stimulus 8) for the FG. Unlike the AG, the FG seems to need more spectral frequencies (200 Hz) to perceive the existence of the pharyngealized sound /sˤ/. The importance difference between the two boundaries indicate that, on average, the boundary for the FG fell to the right of the AG boundary. That is, The FG labeled more stimuli as [s]. A t-test shows a significant boundary difference between the two groups. t(119)= 6,74, p<0.0001.

3.2. Discrimination test

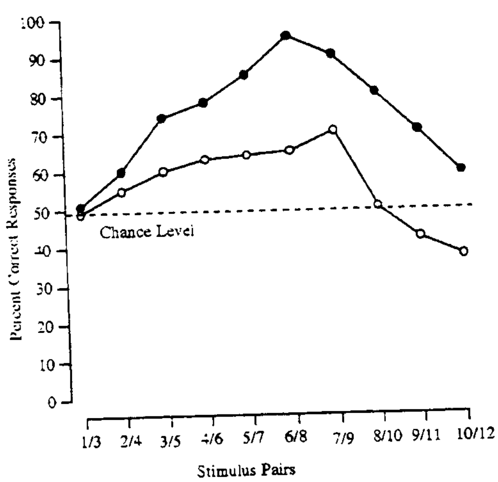

Figure4: Average discrimination functions for the Arabic group (—●—) and French group (—○—) on the /s-sˤ/ series.

Pooled discrimination functions for the Arabic and French groups are displayed in figure 4. A Groups X Comparison Pairs ANOVA was performed. A significant Groups main effect, F(1,18)= 227,89 p<.0001, indicated that FG was less accurate overall in discrimination than was AG. The significant main effect for Comparison Pairs, F(9,162)= 39,01, p<.0001, indicated that overall there were peaks and troughs in discrimination performance. The latter effect was expected by a Comparison Pairs X Groups interaction, F(9,162)= 6,86, p<.0001, indicated that, in general, the FG showed a smaller discrimination peak than the AG.

4. DISCUSSION

Cross-language studies have shown that some non-native speech distinctions present greater perceptual difficulties than others to the adult listeners. Previous research has clearly demnstrated differences in the perception of phonemic versus non-phonemic contrasts [14, 15]. In the present study, this general finding was replicated for a non-phonemic contrast [si]/[sˤi].

AG showed a sharp category boundary and a high discrimination peak while FG showed much less consistent identification and markedly poor discrimination. This group difference is compatible with the fact that [si-sˤi] is phonemic distinction only in Arabic, and that FG perceived this non-native phones on the basis of their phonetic similarity to native language categories.

According to Flege's Speech Learning Model (SLM) [16], if FG perceived [s] as a similar phone, which leads to a perceptual difficulty even after a considerable experience, The pharyngealized phone[sˤi] is perceived as a new phone, whose perception is initially difficult but may improve with linguistic experience by establishing a new phonetic category. Experience with languages using that contrast may lead to a reorganization of perceptual assimilation of non-native phones. That is, experience with Arabic may have shifted FG's categorization and discrimination towards the phonemic and phonetic properties of the pharyngealized/non-pharyngealized contrast employed in Arabic.

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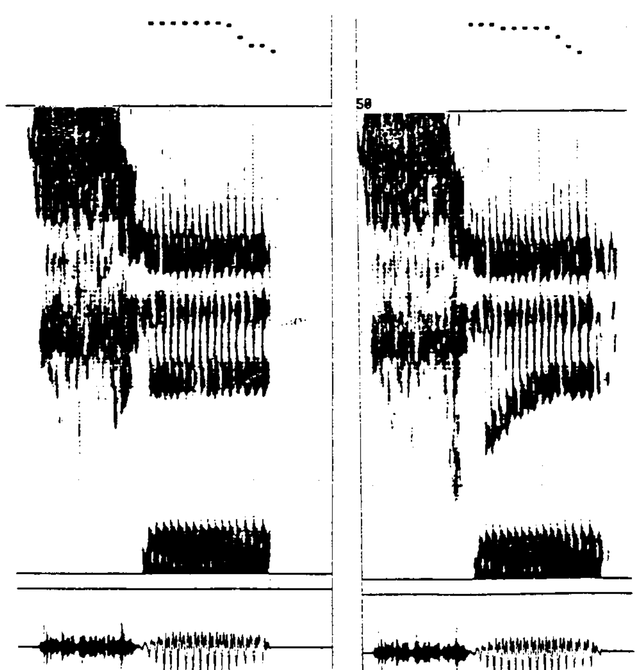

[si] [$s^{\text{ʕ}}$i]

Spectrograms displaying the acoustic structure for the synthetic tokens: the non-pharyngealized token [si] (left) and the pharyngealized one [$s^{\text{ʕ}}$i] (right).