ATTENTION REDISTRIBUTION AND SEGMENT-TONE INTEGRATION IN MANDARIN TONE ACQUISITION BY L2 LEARNERS

Ting Zou [1], Yiya Chen[1,2], Johanneke Caspers [1,2]
[1] Leiden University Center for Linguistics, [2] Leiden Institute for Brain and Cognition

t.zou@hum.leidenuniv.nl, yiya.chen@hum.leidenuniv.nl, j.caspers@hum.leidenuniv.nl

ABSTRACT

This study investigates how beginning and advanced Dutch learners of Mandarin process Mandarin tonal information. An ABX matching to sample task is adopted to investigate the discrimination of tonal pairs, the redistribution of attention between segmental and suprasegmental information, and the integrality of segmental and suprasegmental dimensions. Results show a clear developmental path in tone learning. The advanced learners can discriminate Mandarin tonal contrasts effectively. Moreover, they have learned to redistribute their attention between segmental and suprasegmental information, and they process these dimensions in an integrated manner like Mandarin native speaker. This reflects that the acquisition of new tonal categories in L2 involves a redistribution of attention along acoustic dimensions and the development of segment-tone integration.

Keywords: Dutch learners of Mandarin, lexical tone acquisition, attention redistribution

1. INTRODUCTION

The function of pitch movements varies across languages. For example, for non-tone language speakers, pitch information is mainly used at post-lexical level [7, 18]. Tone language speakers，on the other hand, primarily employ pitch information to convey lexical meanings, while at the same time, in a much more complex and subtle way, f0 signals various types of post-lexical information, as in non-tonal languages [6, 12].

Speakers of tone and non-tone languages have been reported to differentially tune their auditory systems to the same acoustic stimuli, due to the different prosodic systems in their native languages [2, 9, 14]. Braun and Johnson [5] showed that the same pitch movements with different locations on a segmental string could be attended to differentially by Mandarin (tone language) and Dutch (non-tone language) listeners. Mandarin speakers were attentive to a rising pitch contour on both initial and final positions in a disyllabic non-word, which signals a lexical tone in Mandarin. Dutch speakers were only sensitive to the rising contour on the final syllable, which signals a question in Dutch.

Prior studies also consistently show a higher level of interdependency in the processing of segmental and tonal dimensions by native Mandarin speakers than by speakers of non-tone languages such as English and Dutch [15, 17, 19]. That is, these two dimensions are integral and processed simultaneously by Mandarin native speakers.

An interesting issue that arises here is how Dutch learners of Mandarin may process pitch information. Specifically, three research questions are addressed in the present study: 1) can Dutch learners of Mandarin successfully discriminate Mandarin lexical tones? 2) are they able to redistribute their attention to segments and tones and develop integral processing of these two dimensions? 3) what is the developmental trajectory of the Dutch learners' discrimination of non-native tonal contrasts and their segment-tone integrality during the time course of acquiring Mandarin?

To address these questions, four listener groups were recruited for an ABX matching to sample task, with beginning and advanced Dutch learners of Mandarin as target groups and native Mandarin listeners and native Dutch listeners as controls. We used multiple speakers to produce the stimuli to increase phonetic variability and memory load, and this way made the participants classify the target word based on a phonological level of representation.

Our first research question concerns the discrimination of non-native tonal contrasts. Theoretical models have been proposed to account for the difficulties in discrimination and acquisition of non-native contrasts. PAM-L2 [4], based on the Perceptual Assimilation Model (PAM) [3], extends the original PAM from contrast discrimination at the first encounter to the long-term acquisition of second language contrasts. Both models share the assumption that the perceptual system of listeners will automatically assimilate nonnative speech sounds to the closest categories in their native language, and the discrimination of nonnative contrasts can be predicted from the way they are assimilated.

According to these models, there are two possible assimilation scenarios for Dutch learners when processing the contrast of rising tone (Tone 2) and falling tone (Tone 4). In Dutch, pitch contours are mainly used to convey post-lexical meaning, but intonation categories are loosely defined, and the status of post-lexical pitch contrasts is less important than lexical pitch contrasts [5]. So the perception of this tonal pair is most likely to follow the Uncategorized-uncategorized (UU) scenario [3,4]: both sounds fall within the phonetic space, but neither fits any single L1 phonological category. The discrimination performance by L2 learners is predicted to range from fair to very good for this scenario. Alternatively, if nonnative tonal contours are assimilated to the Dutch intonation system, the sequence of falling tone and neutral tone may be mapped onto a pointed hat pitch accent followed by a low boundary tone in Dutch (H*L L%) [13]. The sequence of rising tone and neutral tone, in contrast, can hardly be mapped onto any Dutch intonation category. Therefore, a second scenario is that this pair of pitch patterns may introduce Uncategorized-categorized assimilation, and the discrimination is then expected to be also good.

The segmental and tonal discriminations were investigated in two kinds of ABX trials: a forced-segment condition and a forced-tone condition. In these conditions, participants were forced to classify target word X along, respectively, the segmental or tonal dimension. There is always a mismatch in the other dimension, which therefore cannot be used as a cue for classification. So, comparison of correct classification of the targets in these two conditions would shed light on the proper representation and short-term retention of tonal contrasts, with that for the segmental contrasts as reference.

Our second research question concerns the redistribution of attention to acoustic dimensions in acquisition of new phonetic categories, which has been much less researched. According to Francis & Nusbaum [8], Nosofsky [16], and Goldstone [10, 11], we may assume that L2 learners have to learn to shift attention to a previously ignored phonetic dimension which has an important linguistic role in the target language.

During the course of Mandarin learning, Dutch learners need to adapt to using pitch movements in a lexically distinctive way. For them, the pitch patterns of different tones are not un-perceptible, but are often not strongly attended to in processing Dutch words [5]. So learning tonal categories may involve adjustments in attention distribution among segmental and suprasegmental dimensions in their perceptual space.

The distribution of attention was tested in the comparison of another two types of ABX trials: the segment-and-tone condition and the segment-or-tone condition. In the former condition, target word X matches either A or B along both dimensions; in the latter condition, target word X can be matched along the segmental dimension or tonal dimension, which allows participants to choose freely along either dimension. This latter condition can thus measure the amount of attention listeners implicitly attach to each dimension. The four conditions would also help us to tap further into the issue of integrality between segmental and tonal processing. In particular, we will examine the reaction time (RT) that listeners from each group need to perform the ABX matching to sample task, as a measure of the easiness of separating the two dimensions in their judgements.

To address the third question, we will examine the developmental trajectory of non-native tonal contrast discrimination as well as the attention redistribution and segment-tone integrality by comparing the two learner groups with different levels of proficiency to both native Dutch speakers and Native Mandarin speakers.

2. METHOD

2.1. Participants

15 Dutch controls, 15 Mandarin controls and 30 Dutch learners of Mandarin participated in the experiment. The native Dutch control group consisted of 4 men and 11 women (mean age=20.6, SD=1.3). The native Mandarin control group had 7 men and 8 women (mean age=25.8, SD=1.3). All were from the Northern part of China and could speak standard Mandarin. All the Dutch learners of Mandarin are students of the Chinese Studies program at Leiden University. The beginner group consisted of 7 males and 8 females (mean age=22.0, SD=2.7). Their Mandarin learning and speaking experience varied between 8 and 20 months, and they had never lived in China. The other 15 participants (6 males and 9 females, mean age= 24.6, SD=2.9) were advanced Mandarin learners, who had between 3 and 14 years of Mandarin learning experience, and had spent at least one year in China.

2.2. Materials

Nine pairs of CVCV non-words were selected with Mandarin Tone 2 (a pitch rise) or Tone 4 (a pitch fall) on the initial syllable [5]. The final syllable was always produced with a neutral tone. The vowel set consisted of [a], [i], [u] and [o]. In the consonant set, there are three voiceless pairs of stops (labial: [p]-[p^h]; alveolar: [t]-[t^h]; velar: [k]-[k^h]), two voiceless fricatives (labial: [f], alveolar: [s]), and two nasals (bilabial: [m], alveolar: [n]). In each non-word pair, the vowels were constant, and the consonants in each syllable only differed in place of articulation (e.g. guta vs. duka). The stimuli were recorded by three Beijing Mandarin speakers (two females and one male).

Four types of ABX trials were constructed. In the forced-segment condition, X can only be classified along the segmental dimension (e.g., gúta-dúka-gùta, ´ refers to pitch rise, ` refers to pitch fall). In the forced-tone condition, X can only be classified along the tonal dimension (e.g., gúta-gùta-dúka). In the segment-and-tone condition, X can be classified along both dimensions (e.g., gúta-dúka-gúta). In the segment-or-tone condition, X can be classified along either dimension (e.g., gúta-dùka-dúka).

2.3. Procedures

Participants were seated in front of a computer screen and received instruction to listen to a group of three words (ABX) and to decide whether the third word (X) was more similar to the first one (A) or the second one (B) by pressing “1” or “2” on the keyboard. Within each trial, there was a 600 ms pause between A and B. The critical word (X) then came after a 900 ms pause [5]. The responses and reaction times of the participants were recorded.

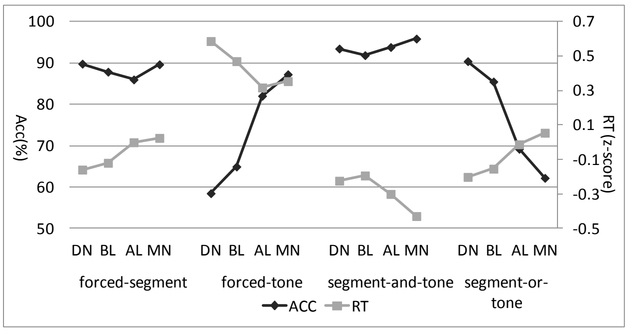
2.4. Statistical analysis

Analysis of accuracy (i.e. correct classification in the forced-segment, forced-tone and segment-and-tone conditions, and percentage of classification along the segmental dimension in the segment-or-tone condition) was performed with a mixed effects logistic regression model using R and the lme4 package [1]. For all trials, a model was constructed with participant group, trial type (forced-segment, forced-tone, segment-and-tone, and segment-or-tone), response button (1 or 2) and their interactions as fixed effects and participants and items as random effects. For reaction time, the raw RT data was transferred to z-scores to achieve better normalcy. The analysis of reaction time was performed with a linear mixed effect model with participant group, trial type, response button and their interactions as fixed effects, and participants and items as random effects.

3. RESULTS

Results of the four participant groups are plotted in Figure 1 with black lines for accuracy (with percentage of correct identification on the left y-axis) and gray lines for reaction time (with z-score reaction time on the right y-axis). On the x-axis are the four groups of participants: Dutch native listeners without Mandarin experience (DN), beginning Dutch learners of Mandarin (BL), advanced Dutch learners of Mandarin (AL), and Mandarin native listeners (MN).

Figure 1: The accuracy and reaction time of four groups of participants in forced-segment, forced-tone, segment-and-tone and segment-or-tone conditions.



In the forced-segment condition, the overall accuracy of segmental discrimination was high across all four participant groups (above 86.0%) with the accuracy of the two learner groups a bit lower than that of the two native groups, but these differences were not statistically significant.

In the forced-tone condition, the accuracy of Mandarin native listeners (MN) (87.2%) and advanced learners (AL) (82.0%) was significantly higher than that of the beginning Dutch learners (BL) (64.9%) and Dutch native listeners (DN) (58.5%) (MN vs. BL: z=5.81, p<.0001; MN vs. DN: z=7.32, p<.0001; AL vs. BL: z=-4.26, p<.0001; AL vs. DN: z=-5.80, p<.0001). Within each subgroup (MN and AL vs. BL and DN), there was no significant difference, but there was a slight trend of Mandarin native listeners performing better than advanced learners, and beginning learners better than Dutch native listeners.

The classification performance in the segment-and-tone and segment-or-tone conditions reveals the distribution of attention between segmental and tonal dimensions. In the segment-and-tone condition, the overall accuracy was very high across the four groups (over 91.0%), and there was no difference among participant groups. In the segment-or-tone condition, the percentage of classification along the segmental dimension was compared. Mandarin native listeners (62.2%) and advanced learners (69.2%) classified the stimuli along the segmental dimension significantly more often than beginning learners (85.5%) and native Dutch listeners (90.4%) (MN vs. BL: z=-6.08, p<.0001; MN vs. DN: z=-7.81, p<.0001; AL vs. BL: z=4.47, p<.0001; AL vs. DN: z=6.24, p<.0001). Within each subgroup, there was again no significant difference, but there was a slight trend of Mandarin native listeners being more attentive to the tonal dimension than advanced listeners, as well as beginning learners being more attentive to the tonal dimension than native Dutch listeners.

For RT measurement, results showed that Mandarin native listeners responded significantly slower in both the forced-segment and forced-tone conditions than in the segment-and-tone condition (z=-10.25, p<.0001; z=-17.70, p<.0001). This suggests that when it was required to direct attention to either the segmental or the tonal dimension, Mandarin native speakers were slowed down by the mismatch in the other dimension. Moreover, the RT in the forced-tone condition was longer than in the forced-segment condition (z=-7.45, p<.0001), which indicates that the mutual integrality between these two dimensions is not symmetrical: the segmental dimension interfered more with judgment in the tonal dimension than vice versa.

For Dutch native listeners, there was no significant difference between RTs in the forced-segment and segment-and-tone conditions, indicating that they totally ignored the variations in the tonal dimension when they were required to direct attention to segmental information only. There was, however, a significant difference in RTs between the segment-and-tone condition and the forced-tone condition (z=-18.33, p<.0001). The longer RT in the forced-tone condition mainly resulted from the difficulty in tonal discrimination (as evident from the accuracy rates), suggesting that the two dimensions were processed separately.

The pattern of the beginning learners was similar to that of Dutch native listeners, with no significant difference in RTs between the forced-segment and segment-and-tone conditions. The significant difference in RTs between the forced-tone and segment-and-tone conditions (z=-14.87, p<.0001) was also a result of difficulty in discriminating tonal contrast. Advanced learners have developed stronger integrality of the segmental and tonal dimensions. Their responses in the forced-segment and forced-tone conditions were significantly slower than that in the segment-and-tone condition (z=-6.85, p<.0001; z=-13.98, p<.0001). The RTs in the forced-tone condition were significantly longer than in the forced-segment condition (z=-7.12, p<.0001), which indicates an asymmetry in the processing of these integral dimensions, similar to that of Mandarin native listeners.

4. DISCUSSION & CONCLUSION

The results of the experiment speak to the three research questions that we set out to address. The discrimination of Mandarin tonal categories was revealed in the forced-tone ABX condition. The performance of advanced learners was significantly better than Dutch native controls and beginning learners, and approximated that of Mandarin native listeners. This suggests that Dutch learners can acquire tonal contrasts effectively with proper practice, which is in line with the prediction of the PAM and PAM-L2 models. Our results are compatible with both scenarios (i.e. the Uncategorized-uncategorized and the Uncategorized-categorized scenario). Further studies are needed to tease apart the two possible assimilation scenarios.

The redistribution of attention between segmental and suprasegmental dimensions was tested in the segment-or-tone condition. Mandarin native listeners were attentive to both dimensions, and adopted both as their classification criteria, while Dutch native listeners uniformly classified the target along the segmental dimension. The performance of beginning learners was similar with Dutch natives, while the advanced learners had learned to shift attention to the suprasegmental dimension and approximated the performance of Mandarin native listeners.

Moreover, for Mandarin native listeners, segmental and suprasegmental dimensions were processed in an integral manner. They were not able to divert their attention from tonal variations when classifying the target along the segmental dimension and vice versa. For Dutch native listeners, the two dimensions were processed separately. The beginning learners demonstrated a pattern like that of the Dutch native listeners. The advanced learners, on the other hand, had developed to process these two dimensions in an integral manner, like Mandarin native listeners.

Our results clearly show the developmental trajectories of L2 learners with different levels of Mandarin proficiency in their processing of segmental versus tonal information. This reflects that learners’ sensitivity to pitch information is flexible. The acquisition of new tonal categories in L2 indeed involves a gradual change in the distribution of attention along acoustic dimensions and the development of segment-tone integrated processing.

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