DOES INTEREST IN LANGUAGE LEARNING AFFECT THE NON-NATIVE PHONEME PRODUCTION IN ELDERLY LEARNERS?

Katri Jähi[1,2], Paavo Alku[3], Maija S. Peltola[1,2]

[1]Department of Phonetics, University of Turku, Finland
[2]Learning, Age and Bilingualism laboratory (LAB-lab), University of Turku, Finland
[3]Department of Signal Processing and Acoustics, Aalto University, Finland
katri.jahi@utu.fi

ABSTRACT

Second language (L2) learning is widely studied in adult learners. This study was conducted in order to see how auditory training affects elderly learners' L2 speech production and whether linguistically oriented seniors can benefit more from training compared to seniors not showing special interest in foreign languages. Hence, we studied seniors recruited from language courses and seniors with other than L2 related interests. The two day study included listen-and-repeat trainings and production tests. The trained words included vowels from which the three first formants and their standard deviations were measured and analysed. The results showed that formant values changed differently as a function of training in the two groups. Also, the standard deviations developed differently: only the linguistically oriented seniors showed a deviation decrease, indicating non-native learning. This study showed that learning to produce a non-native phoneme can be easier for elderly learners who show a general interest in languages.

Keywords: second language learning, speech production, linguistically oriented seniors

1. INTRODUCTION

In speech production sounds can be seen as targets. To reach the right target, speaker needs to reach both articulatory and auditory-perceptual goals [21]. Feedback systems are error-driven and therefore they function slowly in comparison with running speech. Because of this, a feedforward system has been proposed to account for the high fluency. This system develops by reinforcement in childhood. The feedback systems and the feedforward mechanism function in close connection in order to make fluent speech possible [20]. In addition to native language (L1) speech production, the feedback mechanisms play an important role in L2 learning, since new productional targets need to be acquired through trial and error.

Perception of speech sounds is categorical and discrimination of phonemes is easier near category boundaries than within categories [18]. Every L1 phoneme forms a category of its own and each category contains a prototypical representative [17]. According to Kuhl [17], these prototypes function as magnets, drawing the nearby sounds toward the centre making discrimination between speech sound categories easier. Because the prototypes are formed in accordance with L1 phonemes, this magnet effect can interfere acquisition of non-native speech sounds [15].

Differences between phoneme systems cause learning difficulties. According to the Perceptual Assimilation Model (PAM), L2 phonemes are assimilated into the L1 categories on the basis of their perceived gestural similarities. Non-native contrasts can be assimilated into two different native categories without causing any or only mild learning difficulties. Non-native contrasting phonemes can also assimilate into one native category either equally well or the other phoneme can be more similar to the native phoneme. The first situation causes major learning difficulties and the latter results in intermediate difficulties. Finally, non-native sounds can be so dissimilar to the native sounds that they are non-assimilable [3]. Speech Learning Model (SLM) classifies the relations between sound systems into three categories and these relations affect both perception and production [10]. Non-native phonemes can be "identical", "similar" or "new" compared to an L1 phoneme and "similar" ones cause major learning difficulties [11].

Age affects language processing in different ways: for example phonological word retrieval is prolonged by age [13] but syntactic complexity in spoken discourse remains stable during aging [19]. Learning changes also with age and it can be seen in brain structure [5] and activation [9]. There are also studies that show the effect of different backgrounds on cognitive tasks. Good physical condition, for example, can help to preserve cognitive functions [8] e.g. speaking and reading rates [22]. It can be assumed that learning non-native speech sounds will be slower at higher age and even though auditory aging can affect perception, it does not fully explain slower learning [16]. In language learning both L2 perception and production are studied and a widely used method in L2 studies is training (e.g. perceptual or auditory training). Training has been used successfully in adults [6] [14] and in children [23]. Some training studies also concern older adults, but they rarely focus on L2 learning.

The aim of this study was to find out whether participating in foreign language courses preserve the ability to learn new production in elderly learners. Our hypothesis was that studying languages benefits elderly learners when they are learning to produce a non-native phoneme. Because our subjects were interested in language learning, it can be assumed that they were motivated to learn which can further assist learning [12]. Also, learning foreign languages may help maintain the plasticity of non-native production. The subjects trained the production of a non-native vowel on two consecutive days and the productions were recorded and analysed.

2. METHODS

2.1. Subjects

Altogether 20 subjects volunteered and a written consent was obtained prior to testing. The subjects were divided into two groups on the basis of their participation in language courses. Language Group consisted of 11 seniors (aged 62–73 years, mean 67,5 years, 6 females) and they had been retired for 1–15 (mean 7,2) years. They all had studied a foreign language at least once a week for 2–10 (mean 4,9) years. Control Group consisted of 9 seniors (aged 63–71 years, mean 66,2 years, 8 females) who had retired 1–11 (mean 6,3) years earlier. They had not studied any languages, but they all had other interests, e.g. exercising and reading.

The subjects in both Groups were Finnish speaking monolinguals and they had studied Swedish in school for 0 to 9 years. However, they reported to have no or only minor language skill in Swedish and that they rarely heard Swedish. All subjects had normal hearing tested prior to participation with screening audiometer with perceptually relevant frequencies (250, 500, 1000, 2000, 4000 Hz). The study was accepted by The Ethics Committee of the University of Turku, Finland.

2.2. Stimuli

We used two semisynthetic pseudowords /tʉ:ti/ and /ty:ti/ as our stimuli. The first stimulus contained close central rounded vowel /ʉ/ which is not phonologically relevant in the subjects' native language and, therefore, it was chosen as the target word. According to SLM, /ʉ/ is "similar" to native /y/ or /u/ causing major learning difficulties. From the perspective of PAM, /ʉ/–/y/ contrast assimilates to the phoneme /y/, but unequally causing learning difficulties. The formant values in /ʉ/ were F1=338 Hz, F2=1258 Hz, F3=2177 Hz and in /y/ F1=269 Hz, F2=1866 Hz, F3=2518 Hz. The main difference between /y/, /ʉ/ and /u/ is in the F2 values. The stimuli were created using Semi-synthetic Speech Generation method (SSG) [1], for a closer view of the stimuli, see [23].

2.3. Procedure

The subjects participated in the study on two consecutive days. In both recording and training sessions the subjects heard the target and non-target words via Sanako Headset SLH-07 and were advised to repeat the words as precisely as possible. Because of the listen-and-repeat type of training, subjects heard both targets and their own productions, and with feedback mechanism they were able to modify their production if needed. In this study the mismatch negativity (MMN) measurements, discrimination tests (DISC) and identification (ID) tests were also performed, however, we only report results of the production data in this paper. The first day began with two MMN blocks followed by ID and two DISC blocks. Then there was a production test in which subjects produced alternating target and non-target words, 10 times each (Sanako lab100 -software). Finally there were four training blocks: within each block, the probability of the target word was different, but after all training, the subject had listened and repeated both stimuli 60 times. The second day started with the same training blocks. After that two MMN blocks, ID and two DISC blocks were performed and finally production test was performed. Although the training method was articulatory listen-and-repeat training, the subjects also heard the stimuli during other tests of the study.

2.4. Analysis

The obtained acoustic data were analysed with Praat software 5.3.01 [4]. Three first formants (F1, F2 and F3) were measured from the steady state phase of each vowel using the Linear Predictive Coding (LPC) Burg algorithm. Fundamental frequency (F0) was measured in order to avoid outliers. Statistical analysis was performed using the IBM SPSS Statistics 21 software. Both mean and standard deviation of the formant data were analysed using Word (2) × Session (4) × Formant (3) Repeated measures analysis of variance (ANOVA). Further post hoc tests were performed when appropriate.

3. RESULTS

The results of the formant analysis showed the main effects of Word ($F(1,8)=148,788$, $p<0,001$) and Formant ($F(2,36)=1323,502$, $p<0,001$) and an interaction between Word and Formant ($F(1,22)=120,721$, $p<0,001$) showing that subjects produced a difference between target and non-target words. Most interestingly the analysis revealed significant interaction between Session and Group ($F(1,18)=4,988$, $p=0,038$), indicating that the other Group changed their production, while the other Group did not. As we analysed Groups separately, neither showed changes between sessions which may be caused by the standard deviation in the limited data of just one Group. However, a closer examination of the formant values (Table 1) seems to explain the clear Session × Group interaction: formant values of the Groups were numerically different. Neither Group showed no changes in phoneme /y/, therefore, it was changes in /ʉ/ that caused the significant interaction. Overall the change was more prominent in Language Group, since also the F1 values changed.

Table 1: Mean format values for /ʉ/ and /y/ in Sessions 1 and 2 from both Groups.

Mean formant values			F1	F2	F3
Language Group	Session 1	/ʉ/	425	1158	2535
		/y/	387	1782	2407
	Session 2	/ʉ/	447	1169	2548
		/y/	382	1790	2424
Control Group	Session 1	/ʉ/	469	1321	2609
		/y/	406	1917	2506
	Session 2	/ʉ/	463	1301	2574
		/y/	409	1919	2470

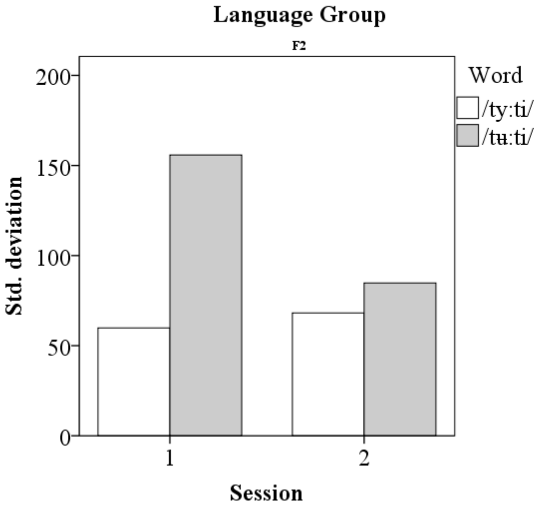
To get more information about consistency of the subjects' productions, we analysed the individual standard deviation values as well. The analysis showed significant main effects of Word ($F(1,018)=23,785$, $p<0,001$) and Formant ($F(2,36)=67,517$, $p<0,001$) and also the interaction between Word and Formant ($F(2,36)=14,131$, $p<0,001$) was significant indicating that the formants in the target and non-target words had different standard deviations on the basis of one of the formants. Most importantly, there was a tendency of interaction of Word × Session × Group ($F(1,18)=3,534$, $p=0,076$) indicating that the standard deviation of the target and non-target words tentatively differed between the Groups in Sessions 1 and 2. On the basis of this tendency and the apparent difference in the F2 standard deviation development (Table 2), we ran post hoc tests for both groups separately.

Table 2: Standard deviation values for /ʉ/ and /y/ in Sessions 1 and 2 from both Groups.

Standard deviation			F1	F2	F3
Language Group	Session 1	/ʉ/	26	156	105
		/y/	17	60	61
	Session 2	/ʉ/	19	85	93
		/y/	23	68	57
Control Group	Session 1	/ʉ/	25	144	82
		/y/	19	64	63
	Session 2	/ʉ/	27	123	91
		/y/	17	52	53

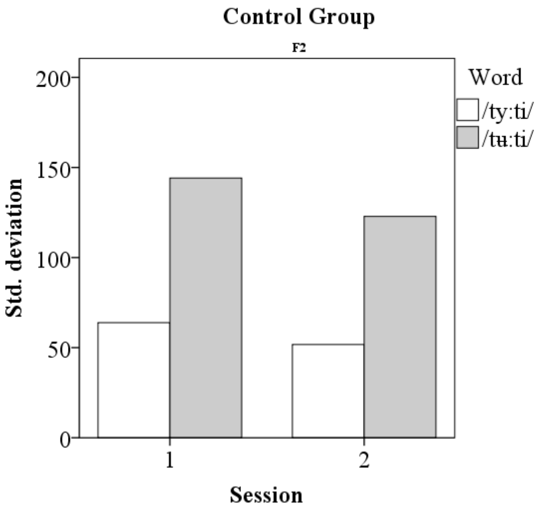
Firstly, we analysed data of Language Group and the analysis revealed significant main effects of Word ($F(1,10)=8,756$, $p=0,014$) and Formant ($F(2,20)=27,098$, $p<0,001$) as well as an interaction between Word and Formant ($F(2,20)=5,349$, $p=0,014$) indicating that there was more variation in the standard deviation of the target or non-target word and also deviations of the formant values varied differently. Most significantly the analysis revealed an interaction between Word and Session ($F(1,10)=5,481$, $p=0,041$) indicating that the standard deviations of the target and non-target words were different in Sessions 1 and 2. To find out what caused the significant interaction, we analysed formants separately. A further analysis with Word (2) × Session (2) ANOVA revealed a Word × Session interaction in F1 ($F(1,10)=9,3767$, $p=0,012$) and in F2 ($F(1,10)=7,946$, $p=0,018$), but not in F3 deviations. Fig. 1 shows clearly, how standard deviation values decreased in F2 in the word /tʉ:ti/ indicating that individuals of the Language Group became more consistent in their productions. Standard deviations of F1 were notably smaller than deviations of F2, which can be seen from Table 2, also, standard deviations of F1 showed a minor decrease in /ʉ/ between Sessions, whereas, in /y/ standard deviations showed a minor increase.

Figure 1: Decrease of the standard deviation values of F2 in Language Group.



Secondly, we analysed the data from Control Group. The analysis showed significant main effects of Word ($F(1,8)=20,351$, $p=0,002$) and Formant ($F(2,16)=61,349$, $p<0,001$) and also an interaction between Word and Formant ($F(2,14)=11,366$, $p=0,002$). However, there were no significant changes in the standard deviations of the target and non-target words between the Sessions, to be more precise, the subjects produced the target and non-target words with the same inconsistency in both sessions. This becomes also evident from the Fig. 2.

Figure 2: The standard deviation values of F2 did not change significantly between Sessions in Control Group.



4. DISCUSSION

The results showed that the elderly learners who were interested in foreign language learning changed their productions of foreign vowel /ʉ/ after only two listen-and-repeat training sessions. Interestingly, elderly learners with no specific interest in foreign languages, showed no changes in production between sessions. These results indicate that studying a foreign language seems to help elderly learners to learn non-native production, in other words, studying a foreign language may help to maintain the plasticity in production of non-native phonemes in elderly learners.

The results of formant analysis showed that Language Group and Control Group produced the target word differently between sessions. Altogether, the formant analysis revealed that the subjects in the Language Group learned to produce the target word in a new manner, while there was no production development in the Control Group. There was shown in the findings that overall change in formant values was more considerable in Language Group as they changed both F1 and F2. In the standard deviation analysis it became evident that the subjects in Language Group became more consistent in their non-native production. In other words, at the beginning of the study there were a wide range of productions from /y/ to /u/ when the subjects tried to reach the target /ʉ/. In Finnish F2 values of /u:/ are around 650 Hz and F2 values of /y:/ around 1995 Hz [24]. Finland-Swedish /ʉ:/ is acoustically between these two Finnish vowels and F2 values of /ʉ/ are around 1000-1200 Hz [2]. As the subjects in Language Group listened the target phoneme closely and repeated it in training sessions, they changed their production and became individually more consistent.

It has been shown that adults can learn to produce foreign speech sounds with auditory training, even though articulatory training can be more useful [7]. Also children are able to learn a non-native speech sound with short and intensive phonetic training [23]. This study showed that elderly people did not benefit from listen-and-repeat training, unless they were interested in language learning in general.

In conclusion, these results show, in accordance with our hypothesis, that general interest in foreign language learning can benefit elderly people as they are learning to produce a non-native phoneme.

5. ACKNOWLEDGEMENTS

The authors would like to thank Sanako, Corp. for providing equipment, software and technical support. We also thank Finnish Cultural Foundation, Varsinais-Suomi Regional fund and Margaretha Foundation for financial support and Maria Vesti, BA for her assistance in data collection. We also thank our subjects for participating in the study.

6. REFERENCES

[1] Alku, P., Tiitinen, H., Näätänen, R. 1999. A method for generating natural-sounding speech stimuli for cognitive brain research. *Clinical Neurophysiology*.110,1329-1333.

[2] Asu, E. L., Schötz, S., Kügler, F. 2009. The acoustics of Estonian Swedish long close vowels as compared to Central Swedish and Finland Swedish. *Proc. Fonetik 2009,* Stockholm.

[3] Best, C.T., Strange, W. 1992. Effects of phonological and phonetic factors on cross-language perception of approximants. *Journal of phonetics* 20, 305-330.

[4] Boersma, P., Weenik, D. 2013. Praat: doing phonetics by computer, version 5.3.0 http://www.fon.hum.uva.nl/praat/.

[5] Boyke, J., Driemeyer, J., Gaser, C., Buchel, C., May, A. 2008. Training-induced brain structure changes in the elderly. *J Neurosci* 28, 7031-7035.

[6] Bradlow, A. R., Akahane-Yamada, R., Pisoni, D.B., Tohkura, Y. 1999. Training Japanese listeners to identify English /r/ and /l/: Long-term retention of learning in perception and production. *Percept Psychophys* 61, 977-985.

[7] Catford, J. C., Pisoni, D. B. 1970. Auditory vs. Articulatory Training in Exotic Sounds*. *The modern language journal* 54, 477-481.

[8] Colcombe, S., Kramer, A. F. 2003. Fitness effects on the cognitive function of older adults: a meta-analytic study. *Psychol Sci* 14, 125-130.

[9] Dennis, N.A., Cabeza, R. 2011. Age-related dedifferentiation of learning systems: an fMRI study of implicit and explicit learning. *Neurobiol Aging* 32, 2318. e17-2318. e30.

[10] Flege, J. E. 1995. Two procedures for training a novel second language phonetic contrast. *Applied Psycholinguistics* 16, 425-442.

[11] Flege, J. E. 1987. The production of “new” and “similar” phones in a foreign language: Evidence for the effect of equivalence classification. *Journal of phonetics* 15, 47-65.

[12] Gardner, R. C., Lalonde, R. N., Moorcroft, R. 1985. The role of attitudes and motivation in second language learning: Correlational and experimental considerations. *Language learning* 35, 207-227.

[13] Geva, S., Jones, P. S., Crinion, J. T., Price, C. J., Baron, J., Warburton, E. A. 2012. The effect of aging on the neural correlates of phonological word retrieval. *J Cogn Neurosci* 24, 2135-2146.

[14] Iverson, P., Evans, B. G. 2009. Learning English vowels with different first-language vowel systems II: Auditory training for native Spanish and German speakers. *J Acoust Soc Am* 126, 866-77.

[15] Iverson, P., Kuhl, P. K., Akahane-Yamada, R., Diesch, E., Tohkura, Y., Kettermann, A., Siebert, C. 2003. A perceptual interference account of acquisition difficulties for non-native phonemes. *Cognition* 87,B47-B57.

[16] Kubo, R., Akagi, M. 2013. Exploring auditory aging can exclusively explain Japanese adults′ age-related decrease in training effects of American English /r/-/l/. *Proc. of Meetings on Acoustics: Acoustical Society of America* Montréal, 060078.

[17] Kuhl, P. K. 1991. Human adults and human infants show a “perceptual magnet effect” for the prototypes of speech categories, monkeys do not. *Percept Psychophys* 50, 93-107.

[18] Liberman, A. M., Harris, K. S., Hoffman, H. S., Griffith, B. C. 1957. The discrimination of speech sounds within and across phoneme boundaries. *J Exp Psychol* 54, 358-368.

[19] Nippold, M. A., Cramond, P. M., Hayward-Mayhew, C. 2014. Spoken language production in adults: Examining age-related differences in syntactic complexity. *Clinical linguistics & phonetics* 28, 195-207.

[20] Perkell, J. S. 2012. Movement goals and feedback and feedforward control mechanisms in speech production. *Journal of Neurolinguistics* 25, 382-407.

[21] Perkell, J., Matthies, M., Lane, H., Guenther, F., Wilhelms-Tricarico, R., Wozniak, J., Guiod, P. 1997. Speech motor control: Acoustic goals, saturation effects, auditory feedback and internal models. *Speech Commun* 22, 227-250.

[22] Ramig, L. A. 1983. Effects of physiological aging on speaking and reading rates. *J Commun Disord* 16, 217-226.

[23] Taimi, L., Jähi, K., Alku, P., Peltola, M. S. 2014. Children Learning a Non-native Vowel – The Effect of a Two-day Production Training. *Journal of Language teaching and research* 5, 1229-1235.

[24] Wiik, K. 1965. *Finnish and English Vowels. A comparison with special reference to the learning problems met by native speakers of Finnish learning English.*Turun yliopisto.