

Production and perception of English /i:/-/ɪ/ and /æ:/-/ʌ/ in a formal setting: Investigating the effects of experience and starting age

Joan C. Mora¹ and Natalia Fullana²

Universitat de Barcelona^{1,2}, University of Ottawa²
mora@ub.edu¹, fullnat@yahoo.es²

ABSTRACT

This study looked at the perception and production of English /i:/-/ɪ/ and /æ:/-/ʌ/ by Catalan/Spanish learners of English varying in starting age of FL learning and FL experience. Results showed that neither starting age nor experience had a significant effect on how accurately participants perceived and produced the two vowel contrasts, although a late starting age advantage was observed as suggested by previous research conducted in formal instruction settings.

Keywords: FL learning, age of onset, experience, vowel production and perception.

1. INTRODUCTION

Much second language (L2) speech acquisition research conducted in immersion settings has examined the effect of age of onset of learning (AOL) of the L2 – understood as any language being acquired after the mother tongue (L1) either naturalistically or through formal instruction – on the production and perception of target language (TL) sounds within the frameworks of Flege's [6] Speech Learning Model (SLM) and Best's [1] Perceptual Assimilation Model (PAM). As a core tenet, both models posit that phonetic learning ability remains intact across the lifespan. More specifically, the SLM predicts that perception (and production) of TL segments will likely be based on learners' L1 phonetic categories after an AOL of 5–7 years, which will result in varying degrees of success in non-natives' L2 sound perception and production. This model further hypothesises that increased L2 experience may lead late learners to discern phonetic differences between L1 and L2 sounds; hence making the establishment of additional phonetic categories for some L2 sounds feasible (and, in turn, their perception and production), as shown in [7]. For the most part, research findings have supported SLM's predictions about AOL (e.g. [15]), whereas the

available studies looking at the factor of experience have to date failed to yield conclusive results on the alleged “beneficial” experience effects. Moreover, the growing number of studies carried out in foreign language (FL) learning contexts – FL referring to the language being learned in the classroom where learners have limited, selected exposure – over the last decade has not only contributed to even more divergent findings of L2 experience effects (e.g. [3]; cf. [5], [14]), but also to somewhat opposing age effects on TL sound perception and production – i.e. a late starting age advantage ([3], [10], [12]).

All of the above points to the need for additional research into starting age and experience effects in a FL learning context, in particular, given the limited amount of experience (or input) often available in formal instructional settings as opposed to that of immersion settings. Thus, the present study aims to further examine native Catalan/Spanish speakers' perception and production of English /i:/-/ɪ/ and /æ:/-/ʌ/ in an effort to determine whether subjects' differing starting ages of FL learning and increased exposure to the TL lead to more accurate perception and production of the often examined tense/lax vowel contrast /i:/-/ɪ/ ([4], [5], [8], [9], [11]) and of /æ:/-/ʌ/, which has been addressed to a lesser extent ([13], [14]).

2. METHOD

2.1. Participants

The participants in this study were 49 Catalan/Spanish bilingual advanced learners (NCS) of English (mean age: 21.2; 33 female, 16 male) studying at university in Barcelona, Spain, all of whom had learnt English mainly through formal classroom instruction in Catalonia. Participants differed in starting age of FL learning – i.e. early childhood, primary, and secondary school – and in

the amount of exposure to the TL – i.e. school exposure only vs. extra exposure throughout schooling. Four native speakers of British English (NE) (1 female, 3 male) with a standard southern accent were recruited as paid informants to provide the spoken words for the construction of a discrimination and imitation task. Some of their productions were also analysed and used as baseline data.

2.2. Materials

A categorial AXB discrimination task and a delayed sentence repetition (DSR) task [15] were used to assess learners' vowel and consonant perception and production. The present paper reports on the vowel data only, namely two FL vowel contrasts: /i:/-/ɪ/ and /æ:/-/ʌ/, which were selected on the basis of their relative difficulty for Catalan/Spanish speakers. Catalan and Spanish do not make use of vowel duration differences contrastively and lack a tense-lax distinction for high vowels, with Catalan and Spanish /i/ occupying approximately the portion of the vowel space occupied by English /i:/ and /ɪ/ ([5]). Consequently, Catalan/Spanish speakers' failure to perceive and produce English /i:/-/ɪ/ successfully is ascribed to their reliance on temporal cues solely, rather than on both spectral and temporal differences ([4]). A front-central distinction for open vowels (/æ:/-/ʌ/) is also lacking in Catalan and Spanish, whose only open vowel is a relatively front /a/. Despite this, /æ/ is often better perceived than produced ([10]), even reaching native-like accuracy levels when delivered in /æ:/-/e/ as opposed to /æ:/-/ʌ/ contrasts [14].

The vowel discrimination task was a forced-choice AXB test consisting of 48 triads with 0.5 sec. inter-stimulus intervals (ISI) and 1.5 sec. inter-trial intervals (ITI) distributed in two blocks. Each block tested participants on a single vowel contrast and contained 24 fully randomized triads per contrasting word pair (*beat-bit*, *peak-pick*, *cap-cup*, *cat-cut*). The DSR task consisted of a set of 8 mini-dialogues (ITI=3sec.) eliciting the 4 target vowel sounds in words in sentence-initial position.

2.3. Procedures

In the AXB task, participants were asked to identify the two words in the triad with the same vowel. The DSR task was administered

individually in a sound-proof booth. The participants heard the dialogues over headphones and their productions were digitally recorded (22.05KHz, 16 bit) and computer-edited for subsequent acoustic analysis with PRAAT [2]. A practice set was provided in both cases.

2.4. Analyses

Vowel formant and duration measures were independently obtained by two researchers and later averaged based on high inter-rater reliability coefficients. The effect of AOL and experience on the participants' ability to accurately perceive and produce the /i:/-/ɪ/ and /æ:/-/ʌ/ vowel contrasts was explored through Kruskal-Wallis and Mann-Whitney U tests. Accuracy in the production of the target vowels with respect to NE informants' vowels (F1, F2, duration) and variation due to contrast type and word were also investigated.

3. RESULTS

3.1. AXB discrimination task

Overall significant differences were observed in the correct discrimination scores between /i:/-/ɪ/ and /æ:/-/ʌ/ [$t(48) = 2.557$, $p < .05$], the tense/lax vowel contrast being discerned at higher correct rates (Table 1). Moreover, the differences in scores between male and female participants yielded significant results in favour of the former [$t(48) = -2.764$, $p < .05$]. On the contrary, differences in scores as a function of starting age and exposure were nonsignificant, though it should be noted that late starters obtained higher correct discrimination scores than earlier starters ($M = 92.70$ for secondary vs. 87.83 and 88.54 for primary and early childhood school, respectively). Contrary to what might be expected, learners with no extra exposure in the period comprised between early childhood and secondary education performed slightly better on the AXB discrimination test than those with extra exposure (range: 1–6 yrs).

Table 1: Significant percent correct discrimination scores on /i:/-/ɪ/ and /æ:/-/ʌ/ (standard deviations are in parentheses)

Contrast	Percent scores ($N = 49$ Ss)	Percent scores	
		Female	Male
/i:/-/ɪ/	88.35 (6.24)	86.99 (6.81)	91.14 (3.68)
/æ:/-/ʌ/	85.35 (8.99)	84.72 (10.13)	85.67 (6.26)

As for the two different word pairs involving /i:/-/ɪ/, in all instances the contrast /i:/-/ɪ/ in *beat-bit* was discerned at higher correct frequency rates than that of *peak-pick* (Table 2), yielding significant differences in the whole-group and gender comparisons. Additionally, all subjects were found to perceive /i:/ and /ɪ/ in *beat-bit* at higher correct rates than in *peak-pick* [$t(48) = 10.183, 3.771, p < .05$]. The same pattern was observed when starting age, experience, and gender were considered.

Table 2: Significant percent correct discrimination scores for /i:/-/ɪ/ and /æ/-/ʌ/ according to word pairs (standard deviations are in parentheses)

Contrast	Percent scores (N = 49 Ss)	Percent scores	
		Female	Male
/i:/-/ɪ/ <i>beat-bit</i> <i>peak-pick</i>	97.57 (6.61) 81.12 (10.45)	94.19 (7.06) 79.79 (11.60)	98.43 (4.53) 83.85 (7.11)
/æ/-/ʌ/ <i>cap-cup</i> <i>cat-cut</i>	84.01 (10.73) 86.05 (11.83)	84.59 (11.43) 84.84 (13.25)	82.81 (9.36) 88.54 (7.97)

Regarding /æ/-/ʌ/ perception, participants' correct discrimination scores were fairly similar as a function of AOL, exposure and gender, as shown in the lack of significant differences in the discrimination of *cap-cup* vs. *cat-cut* (Table 2). On the contrary, NCS were somewhat better at discerning /æ/ than /ʌ/ as the target in the delivered triads (mean range: 87.07–90.47 for /æ/ vs. 80.95–81.63 for /ʌ/).

3.2. Delayed Sentence Repetition Task

In general, no significant differences were observed in the production measures analysed as a function of AOL and exposure, suggesting that neither starting age nor extra exposure to English outside school had any effect on the participants' productive ability. Similarly, gender was found to have no effect on productive accuracy. A closer inspection of the F1, F2 and duration measures obtained revealed that in all cases NCS produced the target vowels with higher F1 and F2 values and longer duration than native speakers, reaching significance in 37.5% of the measures obtained, particularly in duration (Table 3). Significant differences were found for F1 in *peak* ($p = .008$); F2 in *bit* ($p = .023$), *pick* ($p = .033$), *cup* ($p = .005$), and *cut* ($p = .006$); and duration in *cap* ($p = .009$), *cat* ($p = .002$), *cup* ($p = .004$), and *cut* ($p = .003$).

Table 3: Mean F1(Hz), F2 (Hz) and duration (ms) in vowel production (DSR task) for NCS and NE (standard deviations in parenthesis).

word	group	measure		
		F1	F2	Duration
<i>beat</i>	NE	352 (81.1)	2238 (234.7)	138 (15.4)
	NCS	413 (84.1)	2298 (308.4)	137 (27.9)
<i>bit</i>	NE	331 (29.6)	2299 (288.3)	104 (8.4)
	NCS	425 (68.1)	2381 (255.4)	117 (28.7)
<i>peak</i>	NE	420 (48.3)	1947 (326.3)	107 (29.5)
	NCS	427 (65.5)	2299 (285.8)	126 (30)
<i>pick</i>	NE	416 (70.5)	2074 (288.3)	95 (21.1)
	NCS	443 (69.1)	2373 (259)	112 (24.7)
<i>cap</i>	NE	769 (172.2)	1552 (165.5)	112 (31.6)
	NCS	865 (117.4)	1575 (188.9)	150 (26.7)
<i>cup</i>	NE	809 (167)	1589 (11.3)	113 (36.7)
	NCS	841 (126.7)	1624 (220)	161 (27.9)
<i>cat</i>	NE	746 (98.1)	1204 (107.1)	90 (28.9)
	NCS	826 (128.7)	1472 (176.8)	134 (27.8)
<i>cut</i>	NE	827 (69.57)	1255 (124.3)	94 (28.9)
	NCS	799 (115.2)	1561 (206.9)	140 (27.8)

Significant differences between contrasting vowels were also found for both NCS and NE speakers. Whereas NCS mainly relied on duration differences to implement the /i:/-/ɪ/ and /æ/-/ʌ/ contrasts and produced long/short vowels without significant spectral differences, NE consistently produced the /i:/-/ɪ/ contrast with larger F1 and F2 differences in *beat-bit* ($p = .046$) and *peak-pick* ($p = .002$), and the /æ/-/ʌ/ contrast with different F2 values in *cap-cup* ($p = .004$) and *cat-cut* ($p = .006$), but no significant duration differences (Table 4).

Table 4: Significant (*, $p < .05$) F1(Hz), F2 (Hz) and Duration (D) (ms) differences in vowel production (DSR task) for NE and NCS speakers

Contrast	NE			NCS		
	F1	F2	D	F1	F2	D
<i>beat-bit</i>	*					*
<i>peak-pick</i>		*				*
<i>cap-cup</i>		*		*		*
<i>cat-cut</i>		*		*		*

4. DISCUSSION AND CONCLUSIONS

This study looked at the perception and production of English /i:/-/ɪ/ and /æ/-/ʌ/ by 49 Catalan/Spanish learners of English varying in AOL and experience in the FL in a formal learning context.

When the results on the AXB discrimination task were considered, it was found that neither starting age (early childhood, primary, and secondary school start) nor experience (school exposure and extra exposure) had a significant

effect on the correct discrimination scores for the two vowel contrasts. In spite of this, late FL learners (secondary school) tended to discern /i:/-/ɪ/ and /æ:/-/ʌ/ at higher correct rates than early starters (early childhood and primary school), which is in line with previous findings of a late starting age advantage in FL learning contexts [10] [11]). In addition, Catalan/Spanish speakers with no extra exposure outside school perceived vowel contrasts more accurately than those learners with a higher amount of experience. This unexpected finding, though, might corroborate previous research conducted in both formal and naturalistic settings ([4], [5], [14]).

As for the DSR task, participants' performance supported earlier findings of overreliance on the use of temporal cues in the production of /i:/-/ɪ/ ([6], [11]), along with the non-native implementation of spectral differences in /i:/-/ɪ/ and /æ:/-/ʌ/ ([14]) irrespective of AOL and experience.

Finally, the lack of significant starting age effects on both the perception and production of /i:/-/ɪ/ and /æ:/-/ʌ/ should be taken with caution due to unequal size groups. Similarly, (nonsignificant) experience effects should be further investigated by obtaining rather equal size groups and by addressing input quality rather than quantity.

5. ACKNOWLEDGEMENTS

This study was funded by Grant HUM2004-05167/FILO from the Ministerio de Ciencia y Tecnología in Spain. Part of this work was also made possible thanks to a postdoctoral scholarship to the second author by the Secretaría de Estado de Universidades e Investigación del Ministerio de Educación y Ciencia (Spain). The authors would like to thank the *Laboratori de Fonètica* and *Laboratori de Fonètica Aplicada* at the Universitat de Barcelona, Anna Maria Agustí, Cristina Aliaga and Eva Cerviño for help with stimulus preparation and data collection, and all the participants in the study.

6. REFERENCES

- [1] Best, C. T. (1995). A direct realist view of cross-language speech perception. In Strange, W. (ed), *Speech perception and linguistic experience: Issues in cross-language research*. Timonium, MD: York Press, 171-204.
- [2] Boersma, Paul & Weenink, David (2007). Praat: doing phonetics by computer (Version 4.6.05) [Computer program]. Retrieved June 2, 2007, from <http://www.praat.org/>
- [3] Bongaerts, T., van Summeren, C., Planken, B., Schils, E. 1997. Age and ultimate attainment in the pronunciation of a foreign language. *Studies in Second Language Acquisition*, 19, 447-465.
- [4] Cebrian, J. 2002. *Phonetic similarity, syllabification and phonotactic constraints in the acquisition of a second language contrast*. PhD Dissertation. *Toronto Working Papers in Linguistics Dissertation Series*. University of Toronto, Toronto, Canada.
- [5] Cebrian, J. 2006. Experience and the use of non-native duration in L2 vowel categorization. *Journal of Phonetics*, 34, 372-387.
- [6] Flege, J. E. 1995. Second language speech learning: Theory, findings and problems. In W. Strange (Ed.), *Speech perception and linguistic experience: Issues in cross-language research* (pp. 229-273). Timonium, MD: York Press.
- [7] Flege, J. E., Bohn, O.-S., Jang, S. 1997. Effects of experience on non-native speakers' production and perception of English vowels. *Journal of Phonetics*, 25, 437-470.
- [8] Fullana, N., MacKay, I. R. A. 2003. Production of English sounds by EFL learners: The case of /i/ and /ɪ/. In D. Recansens, M. J. Solé, & J. Romero (Eds.), *Proceedings of the 15th International Congress of Phonetic Sciences*. Australia: Causal Productions, 1525-1528.
- [9] Fullana, N., MacKay, I. R. A., Muñoz, C. 2005. A study of FA in FL learners' production of English vowels in a formal setting: Starting age and instruction effects. Poster presented at the *1st ASA Workshop on Second Language Speech Learning*, Vancouver, Canada, May 14-15.
- [10] Fullana, N. 2006. The development of English (FL) perception and production skills: Starting age and exposure effects. In Muñoz, C. (ed), *Age and the rate of foreign language learning*. Clevedon, England: Multilingual Matters, 41-64.
- [11] García Lecumberri, M. L., Cenoz Iragui, J. 1998. Influencia de la duración en la adquisición de las vocales inglesas. In VázquezI, Guillén, I. (Eds.), *Perspectivas pragmáticas en lingüística aplicada* (pp. 201-207). Zaragoza: Textos de Filología, 6, Asociación Española de Lingüística Aplicada (AESLA).
- [12] García-Lecumberri, M. L., Gallardo, F. 2003. English FL sounds in school learners of different ages. In García-Mayo, M. P., García-Lecumberri, M. L. (eds), *Age and the acquisition of English as a foreign language*. Clevedon, England: Multilingual Matters, 115-135.
- [13] Mora, J. C. 2005. Lexical knowledge effects on the discrimination of non-native phonemic contrasts in words and nonwords by Catalan/Spanish bilingual learners of English. *Proceedings of the ISCA Workshop on Plasticity in Speech Perception*. London: Department of Phonetics and Linguistics, University College London, 43-46.
- [14] Mora, J. C. (in press). Learning context effects on the acquisition of a second language phonology. In C. Pérez-Vidal (Coord.), M. Juan-Garau and A. Bel (eds) (in press) *A Portrait of the Young in the New Multilingual Spain*. Clevedon: Multilingual Matters.
- [15] Munro, M. J., Flege, J. E., MacKay, I. R. A. (1996). The effects of age of second language learning on the production of English vowels. *Applied Psycholinguistics*, 17, 313-334.