

Starting Age and Exposure Effects on EFL Learners' Sound Production in a Formal Learning Context

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1. Introduction

Research into second language (L2) acquisition has extensively examined age of onset of L2 learning that might result in successful (or native-like) mastery of the L2. In the specific case of L2 phonological acquisition, Long's (1990) review of available studies pointed to a starting age of 6 years as the upper limit to acquire native-like L2 pronunciation, while indicating that after a starting age of 12 years learners' pronunciation of L2 sounds would be nonnative-like. Traditionally, those findings have been explained in terms of the Critical Period Hypothesis (CPH) (Lenneberg, 1967). However, for some time now alternatives to the neurophysiological maturation account such as Flege's (1995) Speech Learning Model (SLM) and Best's (1995) Perceptual Assimilation Model (PAM) have been formulated, whereby the main cause for the observed age differences in native-like attainment of L2 phonological skills is hypothesized to lie in the learners' first language (L1) and stage of L1 phonological development when L2 learning begins.

Specifically, the SLM holds that age of onset of L2 learning will determine the nativeness of perception and production of target language (TL) sounds (Flege, 1995). In addition, varying degrees of success in nonnatives' perception and production of L2 sounds will depend upon whether learners identify L2 sounds as new or similar to their L1 phonetic categories (Flege, 1991b). Furthermore, the model hypothesizes that as learners' experience in the L2 increases, they may be able to discern phonetic differences between L1 and new L2 sounds, which might then lead to more accurate perception and production of L2 segments (e.g., Flege, Bohn, & Jang, 1997).

Many studies conducted within the SLM framework have focused on foreign accent (FA), as well. Reviewing FA research, Piske, MacKay, and Flege (2001) concluded that starting age of L2 learning (AOL) was the main predictor of degree of FA in the TL – accent found to emerge between the ages of 5 and 8 in L2 naturalistic settings (e.g., Flege & Fletcher, 1992). By contrast, L2 experience, whether understood as length of residence (LOR) or formal instruction or both, has failed to yield conclusive results on the attainment of native-like (or near-native) L2 pronunciation (e.g., Bongaerts, van Summeren, Planken, & Schils, 1997; Cebrian, 2006; Elliott, 1995a, 1995b; Flege & Liu, 2001; Flege, Munro, & MacKay, 1995; Moyer, 1999; Tahta, Wood, & Loewenthal, 1981).

Divergent L2 experience effects abound in studies carried out in formal learning contexts where learners have (very) limited exposure to the foreign language (FL) (e.g., Cebrian, 2003; Fullana & MacKay, 2003, 2004; García-Lecumberri & Gallardo, 2003; Mora & Fullana, 2007; Rallo, 1999). Additionally, inconclusive starting age effects become more evident in formal settings: compare, for instance, Dutch learners' attainment of native-like pronunciation in English despite a late starting age of FL learning (Bongaerts *et al.*, 1997) vs. Spanish/Basque bilinguals' failure to produce English sounds accent-free with AOLs ranging from 4 to 11 years (García-Lecumberri & Gallardo, 2003) and Catalan/Spanish bilinguals with AOLs of 8 to 14 years (Fullana, 2005).

Apart from focusing on the variables of age of onset of L2 learning and experience in the L2, FA research has also explored the relationship between the dimensions of

accentedness, intelligibility, and comprehensibility (Derwing & Munro, 1997; Munro & Derwing, 1995a, 1995b, 2001; Munro, Derwing, & Morton, 2006). In the case of the relationship between foreign accent and intelligibility – the latter defined as “the extent to which the native speaker understands the intended message” (Munro & Derwing, 1997:2) – results have shown that these two dimensions are mostly independent of each other. That is, no matter learners’ various degrees of FA, their sound production in the L2 might still be deemed as highly intelligible (e.g., Munro & Derwing, 1997; Munro, Flege, & MacKay, 1996).

Based on the lack of firm evidence on starting age and experience effects in formal learning settings, the present study aims to further re-examine the factors of age of onset of FL learning and exposure to the FL in an instructed-classroom learning context to help determine their effects on the production of English vowels /i ɪ æ ʊ/ by Catalan/Spanish learners of English as a foreign language (EFL). Moreover, this study addresses the dimensions of accentedness and intelligibility by offering a preliminary insight into the correlation of EFL learners’ FA scores with their respective vowel identification scores.

2. Method

2.1 Participants

The participants in this study are part of the Barcelona Age Factor (BAF) project at the Universitat de Barcelona (Spain). A total of 148 Catalan/Spanish learners of English were distributed into eleven groups differing in starting age of FL learning (8, 11, 14, and 18+ years)¹ and in amount of formal exposure to the TL (2.5, 4.5, and 7.5 years, which corresponded to 200 hours, 415 hours and 726 hours of formal instruction, respectively). A control group of 13 English native speakers (NE) was also included in the study (see Table 1).

Table 1. Characteristics of groups in the study: (a) age of onset of FL learning (in years); (b) exposure to the FL (in years); (c) m: male, f: female; (d) chronological age at testing (in years)

Group	N	(a) AOL	(b) Exp	(c) Gender	(d) Age
A1	17	8	2.5	11 m, 6 f	10.97
A2	27	8	4.5	13 m, 14 f	12.93
A3	13	8	7.5	7 m, 6 f	16.61
B1	13	11	2.5	5 m, 8 f	13.09
B2	14	11	4.5	8 m, 6 f	14.92
B3	15	11	7.5	10 m, 5 f	18.01
C1	13	14	2.5	6 m, 6 f	16.14
C2	4	14	4.5	2 m, 2 f	18.45
D1	23	18+	2.5	18 m, 5 f	28.62
D2	7	18+	4.5	5 m, 2 f	26.25
D3	2	18+	7.5	0 m, 2 f	45.79
NE	13	N/A	N/A	5 m, 8 f	11.62

¹ Due to the scarce (or significantly uneven) number of participants that could be recruited for the older beginner groups (14- and 18-year-olds), the present study will focus on 8- and 11-year-old starters’ performance mainly – 99 learners in total.

2.2 Materials

A production task was designed consisting of repeating a list of 34 English one-syllable words as presented by a female native speaker (NS) of Standard British English via tape recorder. Words contained features of the English sound system reported to be difficult or problematic for Catalan and/or Spanish native speakers (NSs) when it comes to their successful perception and production – both in immersion and formal learning settings – such as the tense/lax vowel distinction, word-final consonant voicing contrast, and consonant clusters in both word-initial and final position (e.g., Cebrian, 2000, 2002b; Flege, 1991a; Flege *et al.*, 1997; Flege, Munro, & Skelton, 1992; Recasens, 1984).

For the present study, three English vowels were chosen for analysis, namely /i ɪ æ/, each produced in two different words (*speak*, *tea*, *it*, *this*, *back*, *pad*), as well as /ʊ/ in one instance only (*zoo*). An attempt was made to select words that contained the segments under study in phonetic contexts that were not thought to have influenced their production to the learners' disadvantage, specifically unvoiced plosive context (but see, for example, Cebrian, 2002c; García-Lecumberri, 1999). As can be observed, the often examined English tense/lax front vowel distinction /i/-ɪ/ was also addressed in this investigation, while the remaining sounds, /æ/ and /ʊ/, were included as they have been considered to a lesser extent in the literature and, when so, results have been somewhat unexpected in the case of Spanish and/or Catalan learners of English (e.g., Flege, 1991a; Flege *et al.*, 1997; Rallo, 2005).

2.3 Listeners

Seven female NSs of General Canadian English participated as paid listeners/judges. They were 26.14 years old on average and students of linguistics at the University of Ottawa. No listener was fluent in either Spanish or Catalan.

Canadian listeners were expected to have been good judges of foreign accent in British English in the accent rating and vowel identification tasks for a number of reasons. At the time of running this aspect of the research, we were aware of some published and other unpublished work concerning the ratings made by NNSs (as noted below). Moreover, Canadian English NSs are regularly exposed to British accents through the media in addition to everyday life, for the local population of British-born residents in Ottawa is high. Furthermore, the judges in this study were exposed a number of times to the same British English exemplars that the participants had been asked to repeat, so they were familiar with the target pronunciations.

Since that time, studies have been published concerning NNS listener/judges. Major (2007) concluded that NS listeners and NNS listeners, as groups, gave similar foreign accent ratings for NS speakers and for NNS speakers. MacKay, Flege, and Imai (2006:176) stated, “nonnative speakers of English are able to gauge foreign accent in English sentences much like NE-speaking listeners.” See also Gallardo, Gómez, & García-Lecumberri (2007). As NNSs have been demonstrated to produce foreign accent ratings similar to NSs, it may have been safe to extrapolate to the ability of NSs of a different dialect to produce foreign accent ratings that are similar to ratings that would be given by NSs of the same dialect.

2.4 Procedure

Based on findings of recommended scales for assessing degree of FA (Southwood & Flege, 1999; Piske *et al.*, 2001), in this study listeners rated subjects' production of English /i ɪ æ ʊ/ on a 9-point scale of FA (1 = no FA, 9 = very strong FA).

Prior to all rating sessions (and blocks), listeners/judges were given both oral and specific written instructions and 5 practice items with a taped model voice, thus familiarizing

themselves with the British English target pronunciation. /i ɪ æ u/ productions were presented each in different random blocks to each judge through headphones via computer. Listeners were further asked to use all the nine points on the FA scale. The ISI was 1.5 seconds, though judges could listen to an item as many times as needed.

For the vowel identification task, listeners were asked to identify the vowel sound that the participants had produced in the words previously rated for degree of FA. In that case, listeners were also provided with a table having 15 response options on the computer screen, from which they had to choose the option that best characterized the vowel segment in question. (For full details about the rating and identification tasks listeners were asked to perform, see Fullana, 2005).

2.5 Analysis

The total number of accent ratings and vowel identifications obtained for 8- and 11-year old beginners' /i ɪ æ u/s was 10,976 (5,488 accent ratings and 5,488 identification scores). If older starters are considered, then the total was 9,359 ratings for each the FA rating task and vowel identification task.

As far as the FA rating is concerned, the intra-class correlation coefficients obtained indicated that for the most part an acceptable degree of intra-listener agreement was achieved (mostly ranging from .70 to .89). Inter-listener agreement was somehow a bit lower. Despite this fact, and for the sake of clarity, listeners' accent ratings were pooled into one single rating.

The effects of starting age of FL learning and exposure to English on Catalan/Spanish learners' /i ɪ æ u/ productions were assessed by means of Kruskal-Wallis analyses and Mann-Whitney *U* tests with the averaged FA ratings on /i ɪ æ u/ as dependent variables.

In the present paper, the effects of the research variables on the vowel identification scores have not been examined at length, though the results obtained were considered at the statistical level when Spearman's Rho correlation coefficients were computed between accent ratings and vowel identification scores. The latter analysis was carried out in an attempt to determine whether a certain (higher) degree of FA on a specific vowel segment would entail a lesser degree of intelligibility (here understood as correct vowel identification) or whether these two dimensions would not interfere with each other (e.g., Derwing & Munro, 1997).

3. Results

As far as the FA rating task was concerned, it can be seen that, for the most part, /i u/ were rated as less foreign-accented than /ɪ æ/ (see Table 2). Furthermore, NE foils obtained significantly less foreign-accented scores than all learner groups ($p < .05$). Among FL learner groups, differences in accent ratings as a function of starting age of FL learning and exposure did not yield significant results. In addition, all vowel sounds under examination were considered to have been produced with a moderate amount of FA. In spite of the lack of significant differences, the following tendencies in Catalan/Spanish NSs' production of English vowels were observed (Figures 1–4).

Table 2. Mean accent scores on /i ɪ æ u/ (1 = No FA, 9 = very strong FA)

Group	/i/	/ɪ/	/æ/	/u/
A1	3.67	3.57	3.92	4.27
A2	4.02	4.13	4.64	4.31
A3	3.73	4.14	5.21	4.89
B1	3.62	4.57	4.85	4.21
B2	4.10	3.96	4.26	3.89
B3	3.95	3.77	4.46	4.80
C1	3.98	4.25	4.61	4.64
C2	3.25	4.26	4.08	3.25
D1	3.70	4.16	4.17	4.19
D2	3.80	4.13	3.97	4.51
D3	3.60	3.96	2.75	4.35
NE	1.46	1.27	1.73	1.97

In the first place, earlier starting age of FL learning (8 years) led to a more foreign-accented production of /i u/ in the short-term of the present study (i.e., after 2.5 years of formal exposure to the FL), whereas it was more advantageous in the production of /ɪ æ/ in the short-term, approaching significance in the production of /ɪ/ ($p = .069$) (see Figures 1–4). By contrast, in the mid- and long-term (i.e., after 4.5 and 7.5 years of exposure), learners with later starting age of FL learning (11 years) produced /ɪ æ/ with a lesser amount of FA (Figures 3–4), while a mixed age effect pattern emerged in their production of /i u/ (Figures 1–2).

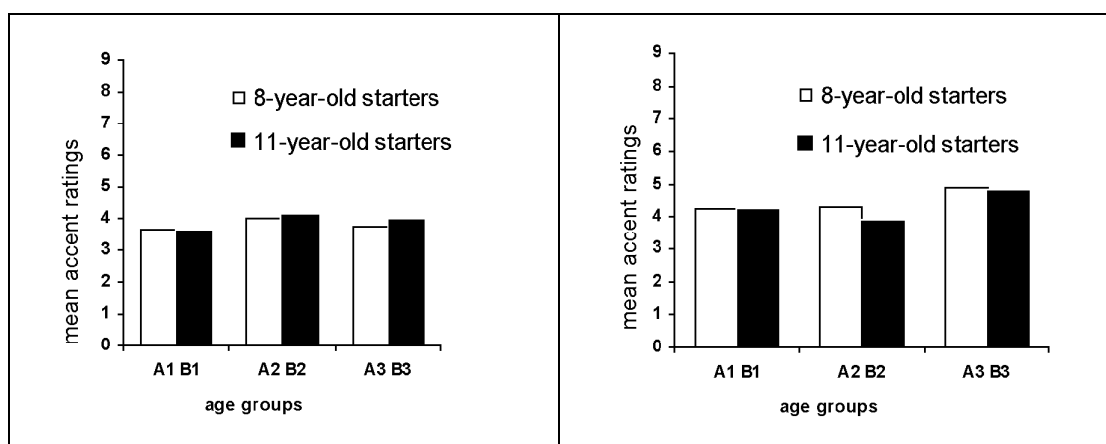


Figure 1. Accent scores on /ɪ/. Factor: AOL

Figure 2. Accent scores on /u/. Factor: AOL

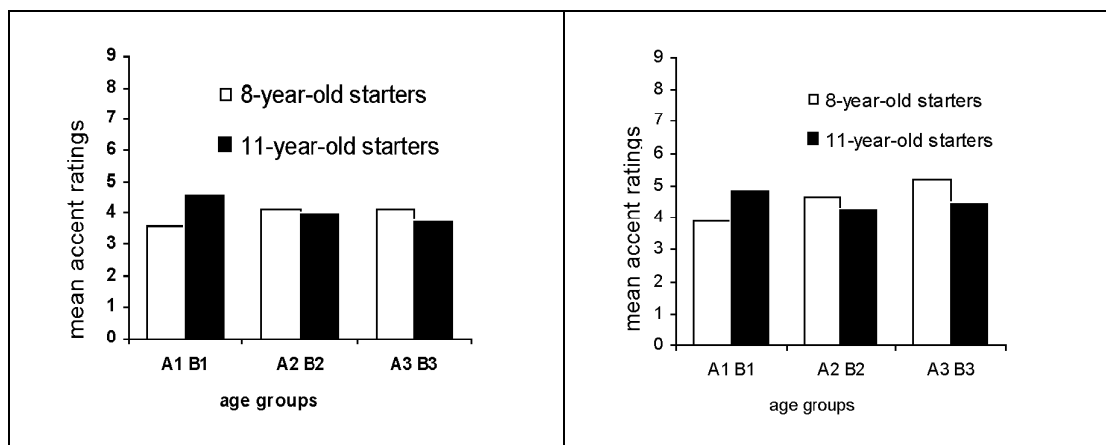


Figure 3. Accent scores on /i/. Factor: AOL

Figure 4. Accent scores on /æ/. Factor: AOL

As for exposure to English, 8-year-old beginners tended to produce English vowels as more foreign-accented as their experience increased; /æ/ in particular was close to being significantly more foreign-accented as learners gained experience in English ($p = .066$). In the main, 11-year-old beginners' production of /i u/ was progressively more foreign-accented, while exposure effects in the expected direction were noted in the production of /i æ/ (see Figures 5–6).

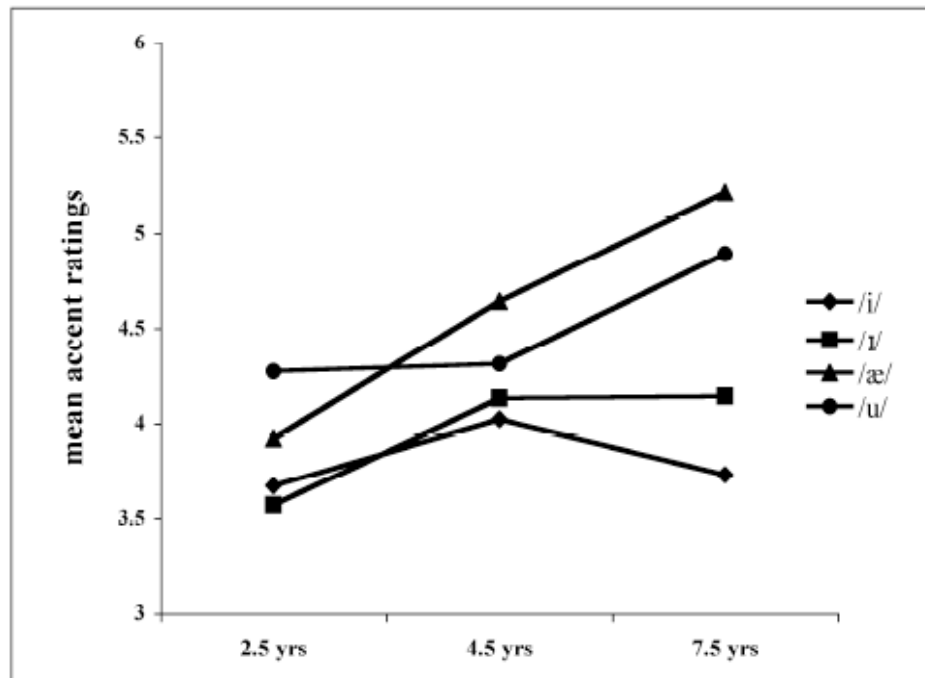


Figure 5. 8-year-old starters' accent scores on /i ɪ æ u/. Factor: exposure to the FL

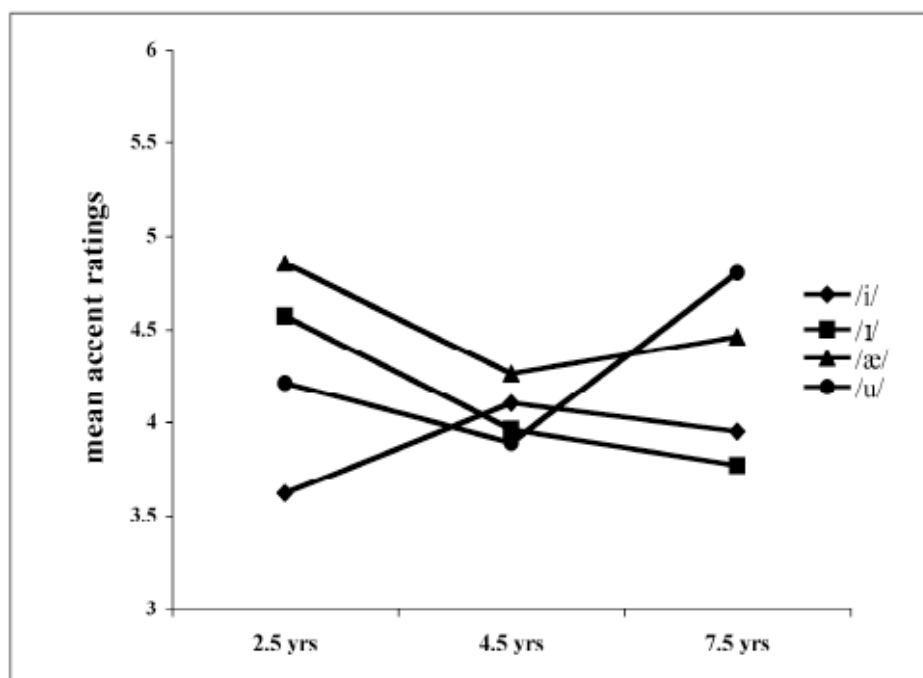


Figure 6. 11-year-old starters' accent scores on /i ɪ æ u/. Factor: exposure to the FL

Findings in the vowel identification task (Table 3) were similar to those observed in the FA rating task. Therefore, the NE group attained significantly higher vowel identification scores than Catalan/Spanish learners of English. Moreover, an earlier starting age advantage was found in the production of /ɪ æ/ in the short-term, whereas the effects of age of onset of FL learning on the four vowels examined were inconclusive in the mid- and long-term. Finally, an increase in formal exposure to the FL resulted in older starters' higher correct identification scores for all vowel sounds (except for /i/), especially in the mid-term. Conversely, 8-year-old beginners produced /i ɪ æ/ as less intelligible as a result of increased exposure to English, though a beneficial exposure effect was noted for /u/.

Table 3. Vowel identification scores (%) on /i ɪ æ u/

Group	/i/	/ɪ/	/æ/	/u/
A1	69.74	60.50	61.76	54.62
A2	64.54	56.87	55.55	58.73
A3	64.28	56.04	46.70	67.09
B1	69.22	51.64	47.79	54.94
B2	64.28	66.32	69.38	74.48
B3	61.90	57.14	60.47	61.90
C1	60.98	56.03	52.09	57.14
C2	71.42	58.92	53.57	75.00
D1	70.80	59.31	64.28	72.04
D2	60.28	66.32	69.38	65.30
D3	64.28	64.28	89.28	71.42
NE	92.85	97.80	89.01	96.70

A further finding of the present study concerned the overall foreign accent ratings on /i ɪ æ u/ and their corresponding identification scores. As shown in Table 4 below, /i/ was on the whole rated as less foreign-accented than /ɪ æ u/. Likewise, the overall percent correct identification scores for /i/ were higher than those of the remaining vowel segments under study. While this might suggest that both the dimensions of accent and intelligibility are interrelated, a look at the Spearman's Rho correlation coefficients and the results for /ɪ æ u/ shows opposing and somehow inconclusive effects. That is, although the correlation coefficient for /i/ was acceptable (-.677) (hence indicating that a lesser degree of FA involves higher identification/intelligibility rates) the results for /u/ ($r = -.668$) point to the contrary – namely, a higher degree of FA does not entail lower identification rates. Finally, when taken together, the correlation coefficients between accent and intelligibility for /ɪ æ/ suggest that the two dimensions are independent of each other (as a similar intelligibility score is obtained for both instances rated as less foreign-accented, on the one hand, and as more foreign-accented).

Table 4. Overall accent ratings and vowel identification scores on /i ɪ æ u/, and Spearman's Rho correlation coefficients between the two dimensions

Vowel	FA ratings	Identification scores	Spearman's Rho
/i/	3.64	68.05	-.677*
/ɪ/	3.85	61.75	-.867*
/æ/	4.20	61.09	-.839*
/u/	4.16	66.01	-.668*

4. Discussion and conclusions

The present study examined the production of English /i ɪ æ u/ by Catalan/Spanish native speakers varying in age of onset of FL learning and amount of exposure to the TL, all of whom had been exposed to English in a formal learning context only. For that purpose, seven Canadian English NS listeners rated EFL learners' vowel production for degree of foreign accent and later identified the vowels as produced by all the participants.

No significant effects of the two factors considered – i.e., starting age and exposure – were found on the accent ratings and vowel identification scores, which is in line with findings of English vowel productions by Catalan/Spanish learners of English in a formal setting with higher degrees of exposure to the FL (Mora & Fullana, 2007). Moreover, the fact that neither starting age of FL learning nor exposure to the FL was a conclusive determinant for Spanish/Catalan speakers' accent-free production of English /i ɪ æ u/ is in agreement with, and extends, previous findings in formal learning contexts (e.g., García-Lecumberri & Gallardo, 2003).

Even though definite starting age and experience effects could not be observed, the finding of the tendency to a later starting age advantage (11 years vs. 8 years) conforms to the reported older beginners' short-lived advantage in the early stages of L2 acquisition (e.g., Snow & Hoefnagel-Höhle, 1977). Thus, all the learners in this study might up to a point be considered as being still in the first stages of FL learning, since the long-term exposure of the present investigation – 7.5 years – corresponds, in fact, to 726 hours of formal instruction in English. Accordingly, learners' failure to perform at native-like levels can be taken as an indication of the differences in amount of input noted for immersion vs. formal learning contexts (Gallardo & García-Lecumberri, 2006; García-Lecumberri & Gallardo, 2003; Singleton, 1995).

Besides, the various age groups' production of English /i ɪ æ u/ with a noticeable degree of FA (though not consistently higher or lower for any group) is in line with the prediction of the SLM about AOLs after the establishment of L1 phonetic categories. That is, an age of onset of L2 learning once after L1 phonetic categories have been established – namely 5–7 years – will likely determine the extent to which L2 vowels are produced (and perceived) in a native-like manner. In addition, learners' failure to perform at native-like levels in this study and, in some instances, more foreign-accented sound production as a function of exposure might be interpreted in light of Flege's (1991b) "accented L2 input hypothesis".

Furthermore, the mixed exposure and age effects on the FA ratings and vowel identification scores for /i ɪ æ u/ are hard to reconcile with earlier accounts of tentative classifications of L2 sounds as "similar" or "new" sounds (e.g., Flege, 1991a). Therefore, the model suggests that it might be possible to perceive and produce "new" L2 sounds in a native-like way after an AOL of 5–7 years and provided that learners have access to sufficient input in the L2 (Flege, 1991b). Following the criteria of acoustic analysis of vowel space of L1 and L2 segments and orthographic classification of sounds, Flege (1991a) hypothesized that native Spanish speakers would regard English /i æ/ as "new" L2 sounds. Taking all of the above into consideration, in this study EFL learners might have displayed production "difficulties" for /i u/ ("similar" L2 sounds), whereas their production of /i æ/ ("new" L2 sounds) – along with an increase in exposure to English and irrespective of starting age of FL learning – might have approached that of English NSs. Thus, although in this study 11-year-old beginners produced /i æ/ with a lesser degree of FA than that of /i u/, 8-year-old beginners tended to produce the four vowel sounds as more foreign-accented as exposure to the FL increased. Moreover, when vowel identification scores were considered, there was no consistent pattern as to which sounds – "similar" or "new" – were identified as correct instances of /i ɪ æ u/ as a function of starting age and exposure.

Finally, preliminary evidence on the study of the relationship between accent ratings and vowel identification scores failed to provide an account for the degree (or lack of) of correlation of the dimensions of accent and intelligibility in FL learning settings. However, it should be noted that the correlation analyses undertaken were mainly focused on an overall mean for accent ratings, on the one hand, and identification scores, on the other hand. Thus, further analyses addressing the relationship between accentedness and intelligibility should be carried out for each EFL learner group separately, particularly if one seeks to explain the differential effects of starting age and exposure reported for each of the vowels under examination in this study.

To sum up, in accordance with previous findings in formal learning contexts, in this study age of onset of FL learning and exposure to English did not result in Catalan/Spanish speakers' accent-free production of English /i ɪ æ u/. Moreover, the results suggest that a starting age earlier than 8 years and more than 7.5 years of formal instruction are needed to produce FL sounds at a native-like level in a strictly formal learning context.

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References

- Best, C. T. (1995). A direct realist view of cross-language speech perception. In W. Strange (Ed.), *Speech perception and linguistic experience: Issues in cross-language research* (pp. 171-204). Timonium, MD: York Press.
- 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.
- Cebrian, J. (2000). Transferability and productivity of L1 rules in Catalan-English interlanguage. *Studies in Second Language Acquisition*, 22, 1-26.
- Cebrian, J. (2002a). Acquiring a new vowel contrast: The perception of English tense and lax vowels by native Catalan subjects. In A. James & J. Leather (Eds.), *New Sounds 2000. Proceedings of the Fourth International Symposium on the Acquisition of Second-Language Speech* (pp. 48-57). Klagenfurt: University of Klagenfurt.
- Cebrian, J. (2002b). Phonetic similarity and acoustic cue reliance in the perception of a second language contrast. In M. Barrio, M. H. Cuenca, J. Díaz, L. F. Rodríguez, & J. A. Vidal (Eds.), *Actas del II Congreso de Fonética Experimental* (pp. 124-128). Sevilla: Universidad de Sevilla.
- Cebrian, J. (2003). Input and experience in the perception of an L2 temporal and spectral contrast. In D. Recasens, M. J. Solé, & J. Romero (Eds.), *Proceedings of the 15th International Congress of Phonetic Sciences* (pp. 2297-2300). Barcelona/Australia: Causal Productions.
- Cebrian, J. (2006). Experience and the use of non-native duration in L2 vowel categorization. *Journal of Phonetics*, 34, 372-387.
- Derwing, T. M., & Munro, M. J. (1997). Accent, intelligibility, and comprehensibility. Evidence from four L1s. *Studies in Second Language Acquisition*, 19, 1-16.
- Elliott, A. R. (1995a). Field independence/dependence, hemispheric specialization, and attitude in relation to pronunciation accuracy in Spanish as a foreign language. *The Modern Language Journal*, 79, 356-371.
- Elliott, A. R. (1995b). Foreign language phonology: Field independence, attitude and the success of formal instruction in Spanish pronunciation. *The Modern Language Journal*, 79, 530-542.
- Flege, J. E. (1991a). The interlingual identification of Spanish and English vowels: Orthographic evidence. *The Quarterly Journal of Experimental Psychology*, 43, 701-731.
- Flege, J. E. (1991b). Perception and production: The relevance of phonetic input to L2 phonological learning. In T. Huebner, & C. A. Ferguson (Eds.), *Crosscurrents in second language acquisition and linguistic theories* (pp. 249-290). Philadelphia: John Benjamins.
- 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.
- 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.
- Flege, J. E., & Fletcher, K. L. (1992). Talker and listener effects on degree of perceived foreign accent. *Journal of the Acoustical Society of America*, 91, 370-389.
- Flege, J. E., & Liu, S. (2001). The effect of experience on adults' acquisition of a second language. *Studies in Second Language Acquisition*, 23, 527-552.
- Flege, J. E., Munro, M. J., & MacKay, I. R. A. (1995). Factors affecting strength of perceived foreign accent in a second language. *Journal of the Acoustical Society of America*, 97, 3125-3134.
- Flege, J. E., Munro, M. J., & Skelton, L. (1992). Production of the word-final English /t/-/d/ contrast by native speakers of English, Mandarin, and Spanish. *Journal of the Acoustical Society of America*, 92, 128-143.
- Fullana, N. (2005). *Age-related effects on the acquisition of a foreign language phonology in a formal setting*. PhD dissertation, Universitat de Barcelona, Spain.

- Fullana, N., & MacKay, I. R. A. (2003). Production of English sounds by EFL learners: The case of /i/ and /ɪ/. In D. Recasens, M. J. Solé, & J. Romero (Eds.), *Proceedings of the 15th International Congress of Phonetic Sciences* (pp. 1525-1528). Barcelona/Australia: Causal Productions.
- Fullana, N., & MacKay, I. R. A. (2004). FL learners' production of English vowel sounds: Effects of starting age and formal instruction on the degree of FA. Paper presented at the XIV EUROSLA Conference, San Sebastián, Spain.
- Gallardo, F., & García-Lecumberri, M. L. (2006). Age effects on single phoneme perception for learners of English as a foreign language. In C. Abello-Contesse, R. Chacón-Beltrán, M. D. López-Jiménez, & M. M. Torreblanca-López (Eds.), *Age in L2 acquisition and teaching* (pp. 115-131). Bern, Switzerland: Peter Lang.
- Gallardo, F., Gómez, E., & García-Lecumberri, M. L. (2007). The assessment of foreign accent by native and non-native judges. *Proceedings of the Phonetics Teaching & Learning Conference 2007*. Retrieved 15 November 2007, from http://www.phon.ucl.ac.uk/ptlc/ptlc2007_web_procindex.html.
- García-Lecumberri, M. L. (1999). Influencia del tratamiento fonético en la percepción de vocales inglesas en una situación de L2. In J. de las Cuevas, & D. Fasla (Eds.), *Contribuciones al estudio de la lingüística aplicada* (pp. 181-188). Logroño, Spain: Gráficas Ochoa.
- García-Lecumberri, M. L., & Gallardo, F. (2003). English FL sounds in school learners of different ages. In M. P. García-Mayo, & M. L. García-Lecumberri (Eds.), *Age and the acquisition of English as a foreign language* (pp. 115-135). Clevedon, England: Multilingual Matters.
- Lenneberg, E. H. (1967). *Biological foundations of language*. NY: Wiley.
- Long, M. H. (1990). Maturational constraints on language development. *Studies in Second Language Acquisition*, 12, 251-285.
- MacKay, I. R. A., Flege, J. E., & Imai, S. (2006). Evaluating the effects of chronological age and sentence duration on degree of perceived of foreign accent. *Applied Psycholinguistics*, 27, 157-183.
- Major, R. C. (2007). Identifying a foreign language in an unfamiliar language. *Studies in Second Language Acquisition*, 29, 539-556.
- Mora, J. C., & Fullana, N. (2007). Production and perception of /i:/-/ɪ/ and /æ/-/ʌ/ in a formal setting: Investigating the effects of experience and starting age. In J. Trouvain, & W. J. Barry (Eds.), *Proceedings of the 16th International Congress of Phonetic Sciences* (pp. 1613-1616). Saarbrücken, Germany.
- Moyer, A. (1999). Ultimate attainment in L2 phonology. *Studies in Second Language Acquisition*, 21, 81-108.
- Munro, M. J., & Derwing, T. M. (1995a). Foreign accent, comprehensibility and intelligibility in the speech of second language learners. *Language Learning*, 45, 73-97.
- Munro, M. J., & Derwing, T. M. (1995b). Processing time, accent and comprehensibility in the perception of native and foreign-accented speech. *Language and Speech*, 38, 289-306.
- Munro, M. J., & Derwing, T. M. (2001). Modeling perceptions of the accentedness and comprehensibility of L2 speech. The role of speaking rate. *Studies in Second Language Acquisition*, 23, 451-468.
- Munro, M. J., Derwing, T. M., & Morton, S. L. (2006). The mutual intelligibility of L2 speech. *Studies in Second Language Acquisition*, 28, 111-131.
- 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.
- Piske, T., MacKay, I. R. A., & Flege, J. E. (2001). Factors affecting degree of perceived foreign accent in an L2: A review. *Journal of Phonetics*, 29, 191-215.
- Rallo, L. (1999). Speaking-rate effects in voiceless stops produced by Catalan speakers of English. In J. J. Ohala, Y. Hasegawa, M. Ohala, D. Granville, & A. Bailey (Eds.), *Proceedings of the 14th International Congress of Phonetic Sciences* (pp. 1417-1420). San Francisco/Berkeley, CA: Department of Linguistics.

- Rallo, L. (2003). Learning a second language influences perception of L1 sounds. In D. Recasens, M. J. Solé, & J. Romero (Eds.), *Proceedings of the 15th International Congress of Phonetic Sciences* (pp. 1517-1519). Barcelona/Australia: Causal Productions.
- Rallo, L. (2005). *Acquisition of a second language vowel system: The case of Catalan learners of English*. Unpublished PhD dissertation, Universitat de Barcelona, Spain.
- Recasens, D. (1984). *Estudi comparatiu de la fonètica segmental del català i de l'anglès*. Barcelona: Edicions ICE.
- Singleton, D. (1995). A critical look at the Critical Period Hypothesis in second language acquisition. In D. Singleton, & Z. Lengyel (Eds.), *The age factor in second language acquisition. A critical look at the Critical Period Hypothesis* (pp. 1-29). Clevedon, England: Multilingual Matters.
- Snow, C., & Hoefnagel-Höhle, M. (1977). Age differences in the pronunciation of foreign sounds. Reprinted in S. D. Krashen, R. C. Scarcella, & M. H. Long (Eds.) (1982), *Child-adult differences in second language acquisition* (pp. 84-92). Rowley, MA: Newbury House.
- Southwood, M. H., & Flege, J. E. (1999). Scaling foreign accent: Direct magnitude estimation versus interval scaling. *Clinical Linguistics & Phonetics*, 13, 335-349.
- Tahta, S., Wood, M., & Loewenthal, K. (1981). Foreign accents: Factors relating to transfer of accent from the first language to a second language. *Language and Speech*, 24, 265-272.