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Developing Non-Native Vowel Representations: A Study on Child Second Language Acquisition

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Abstract

This study examines what stage 9-12-year-old Dutch-speaking children have reached in the development of their L2 lexicon, focusing on its phonological specificity. Two experiments were carried out with a group of Dutch-speaking children and adults learning English. In a first task, listeners were asked to judge Dutch words which were presented with either the target Dutch vowel or with an English vowel synthetically inserted. The second experiment was a mirror of the first, i.e. with English words and English or Dutch vowels inserted. It was examined to what extent the listeners accepted substitutions of Dutch vowels by English ones, and vice versa. The results of the experiments suggest that the children have not reached the same degree of phonological specificity of L2 words as the adults. Children not only experience a strong influence of their native vowel categories when listening to L2 words, they also apply less strict criteria.

The present study deals with the development of phonological representations in the mental lexicon of child second language learners. On the basis of behavioral data, it aims to answer the question whether child and adult listeners create two separate sets of phonological categories for their native and non-native languages, and how specific

these categories are, or whether they use their native phonological categories for sounds in the non-native language. A number of previous studies have addressed the acquisition of non-native phonological representations by early and late second language learners or bilinguals (a.o. Polka & Bohn, 2003, 2011; Sebastián-Gallés, Echeverría & Bosch, 2005; Simon, Sjerps & Fikkert, 2013). Sebastián-Gallés et al. (2005) asked Catalan-Spanish bilinguals to conduct a lexical decision task with Catalan words and nonwords, in which the Catalan vowel /ɛ/ was replaced by the Catalan vowel /e/, or vice versa. They found that Spanish-Catalan bilinguals did not perform at the same level as Catalan-Spanish listeners, indicating that there is interaction between the two languages of bilingual listeners. Similar experiments involving Spanish-learning, Catalan-learning and bilingual children are reported in Ramon-Casas, Swingley and Sebastián-Gallés (2009) and support the observation that even simultaneous bilinguals do not treat the two languages in the same way as monolingual native speakers do. Simon, Sjerps and Fikkert (2013) examined the phonological representations of vowels in children's native and non-native lexicon by means of two mispronunciations tasks involving native and non-native words in which the vowels were replaced by other vowels from the same language. The results revealed that, while the 9-12-year-old children had well-developed and determinate phonological representations of native vowels, the phonological representations of non-native vowels were still under development. Especially for vowel contrasts which did not occur in the listeners' native language, such as the English /ɛ-æ/ contrast, which does not exist in Dutch (Dutch only has /ɛ/), listeners had underspecified representations.

This study more directly tests the role of the native phonology in such underspecification. It addresses the question how phonological representations are organized in the native and nonnative mental lexicon by means of two cross-language mispronunciation detection tasks, in which vowels from the non-native language are inserted in native words, or vice versa. The listeners were the same as those in Simon, Sjerps and Fikkert (2013), i.e. 9-12-year-old Dutch-speaking children learning English. As pointed out in Simon, Sjerps and Fikkert (2013), native and non-native perception by infants has been examined in a large number of recent studies (Bosch & Ramon-Casas, 2011; Kuhl, Stevens, Hayashi, Deguchi, Kiritani & Iverson, 2006; Polka, Rvachew & Molnar, 2008), but studies on the native and non-native perception of school-age children are rare. Exceptions are Flege & Eeftink, 1986; Hazan & Barrett, 2000; Johnson,

2000; Parnell & Amerman, 1978; Simon, Sjerps & Fikkert, 2013; Walley & Flege, 1999 (see Simon, Sjerps & Fikkert for a discussion). In a first word-picture verification experiment, child listeners were presented with Dutch words which were either pronounced with the target Dutch vowel, or with an acoustically similar English vowel inserted in the Dutch consonantal frame. The second experiment was a mirror of the first, this time with English words which were pronounced correctly or which were mispronounced with a Dutch vowel. It will be examined to what extent child and adult listeners accepted substitutions of Dutch vowels by English ones, and vice versa, and which vowel substitutions were accepted or rejected. The assumption is that if listeners accept words in which the Dutch vowel was replaced by an English one, as in the Dutch word *boom* ('tree') realized with the English /ɔ/, as [bɔm], or in which the English vowel was replaced by a Dutch one, as in the English word *ball* realized with the Dutch /o/ vowel, as [bol], this means that they use just one, underspecified phonological representation for these vowels. If they reject such mispronunciations, this suggests that they apply strict criteria for the quality of their (native or non-native) vowels. The child data will be compared to data from proficient adult second language speakers.

EXPERIMENT 1: DUTCH WORDS WITH ENGLISH VOWELS

Participants

The participants were 25 monolingual native speakers of Dutch, recruited in three primary schools in Flanders. They were all between the ages of 9 and 12. Since formal English education in Flanders starts only in secondary school, the children had not had English classes. Some children had had a few hours of content-based learning in school, mainly consisting of playing games and learning songs. They had had no English tests, exams or homework assignments. None of the children had known hearing deficits or concentration problems.

There was a control group of sixteen adult monolingual native speakers of Dutch (aged between 18 and 20), who also performed the experiment. They were all 2nd or 3rd year university students of English, who were highly proficient in English.

Stimuli

The stimuli were based on 16 monosyllabic Dutch words, in which the vowel was synthetically replaced either by an English vowel, or by

another realization of the target Dutch vowel. The Dutch words and English non-words on which the synthetic stimuli were based, were produced in Dutch and English carrier phrases by a female, bilingual Dutch-English speaker. The recordings were made with a Marantz Professional solid state recorder (PMD620) and a Sony condenser microphone (ECM-MS907). To insert the vowels into the consonantal frames the on- and offsets of the vowels were indicated in both the frames and the target vowel recordings. The vowel part in the frame was then faded out over a 20 ms time window, while for the target vowels the vowel was faded in over a 20 ms time window. These files were then combined by addition over time. Dutch and English vowels were selected which are acoustically close. The stimuli were organized in three lists in which different words occurred with their target Dutch vowel and the English vowel substitutions. The three lists were presented with optional breaks in-between and the items were randomized within each list. The stimuli list is presented in Table 1.

Table 1. Stimuli list in Experiment 1. Stimuli in bold present frames with the target Dutch vowel synthetically inserted.

Dutch vowel	Dutch word	frame	List 1	List 2	List 3
/ɛ/	pet ('cap')	[p_t]	**[pɛt]**	[pɛt]	[pɪt]
	web ('web')	[w_b]	[wɪb]	**[wɛb]**	[wɛb]
	mes ('knife')	[m_s]	[mɛs]	[mɪs]	**[mɛs]**
	tent ('tent')	[t_nt]	**[tɛnt]**	**[tɛnt]**	**[tɛnt]**
/ɑ/	tak ('branch')	[t_k]	**[tɑk]**	[tɛk]	[tæk]
	bad ('bath')	[b_t]	[bæt]	**[bɑt]**	[bɛd]
	dak ('roof')	[d_k]	[dɛk]	[dæk]	**[dɑk]**
	kat ('cat')	[k_t]	**[kɑt]**	**[kɑt]**	**[kɑt]**
/o/	spook ('ghost')	[sp_k]	**[spok]**	[spɔk]	[spuk]
	poot ('paw')	[p_t]	[put]	**[pot]**	[pɔt]
	boot ('boat')	[b_t]	[bɔt]	[but]	**[bot]**
	noot ('nut')	[n_t]	**[not]**	**[not]**	**[not]**
/u/	hoed ('hat')	[h_t]	**[hut]**	[hɔt]	[hut]
	stoel ('chair')	[st_l]	[stul]	**[stul]**	[stɔl]
	voet ('foot')	[v_t]	[vɔt]	[vut]	**[vut]**
	koe ('cow')	[k_]	**[ku]**	**[ku]**	**[ku]**

Task and Procedure

The experiment was supported by Superlab 4.0. Listeners were individually tested in a quiet room in their school. They were seated in front of a computer screen and were presented with a picture of an object followed after 1500 ms by an audio stimulus. They were instructed to judge whether the word they heard was pronounced 'correctly' or 'incorrectly' and were asked to provide their response by pressing a blue button marked 'juist' (*right*), or a red button marked 'fout' (*wrong*) on an RB-730 response pad. The experiment started after three practice trials.

Results

In the presentation of the results of Experiment 1, Dutch words in which another instance of the original Dutch vowel was inserted, are referred to as 'correct pronunciations' (CPs), while Dutch words in which an English vowel was inserted are referred to as 'mispronunciations' (MPs).

Figure 1 presents the proportion of 'yes' responses to Dutch words that either contained the correct Dutch vowels (two leftmost bars: CPs) or English vowels (two rightmost bars: MPs). The data from the 25 child participants are displayed in the black bars; those from the 16 adult participants in the grey bars.

The top panel of Figure 1 displays the proportion of 'yes' scores. Analyses were performed on logit-transformed data. Overall, children and adults gave similar proportions of 'yes' responses: $F(1,39) = 0.42$, $p = 0.523$, $\eta p2 = 0.011$. 'Yes' responses to CPs (i.e. Dutch words containing Dutch vowels) were significantly more frequent than 'yes' responses to MPs (i.e. Dutch words containing English vowels): $F(1,39) = 1191.38$, $p < 0.001$, $\eta p2 = 0.968$. The high proportions of 'yes' responses to the CP stimuli indicate that the manipulated stimuli, in which the vowels in Dutch words were replaced by other realizations of the same Dutch vowels, sounded natural to the listeners, and did not lead to false rejections. No interaction was observed between Stimulus Language and Age Group: $F(1,39) = 0.47$, $p = 0.495$, $\eta p2 = 0.012$.

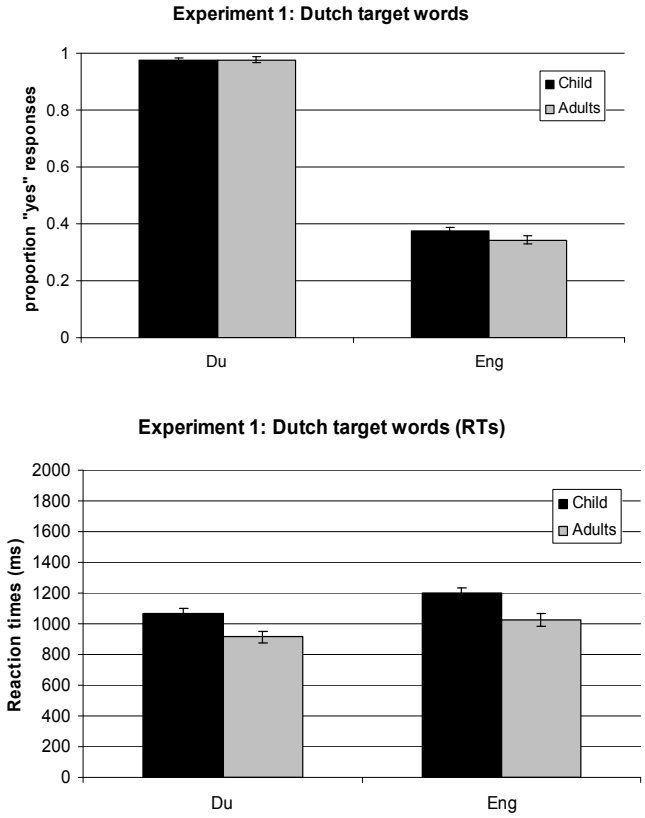


Figure 1. Dutch task: Proportion of 'yes' responses (left panel) and RTs (measured from sound onset) with indication of the standard error of the mean.

The bottom panel of Figure 1 displays Reaction Times (RTs). Analyses were performed on logit transformed data[1]. The panel displays averaged RT data that were back transformed from those LogRT data. Overall, the children responded more slowly than the adults: $F(1,39) = 15.54$, $p < 0.001$, $\eta_p^2 = 0.285$. Furthermore, participants responded more slowly to words containing English vowels than to those containing Dutch vowels: $F(1,39) = 50.42$, $p < 0.001$, $\eta_p^2 = 0.564$. No interaction was found between Stimulus Language and Age Group: $F(1,39) < 0.001$, $p = 0.973$, $\eta_p^2 < 0.001$.

Table 2 presents the results for each vowel (number of 'yes' responses) for the MPs involving Dutch words in which the vowel was substituted by an English one.

[1] For each participant, those RTs that lay two standard deviations (sd) above or below their (log transformed) means were replaced with the respective values of two sd away from their mean, to avoid missing data.

Table 2. 'Yes' responses to Dutch mispronunciations by children and adults.

Target Dutch vowel	Substituting English V	Children	Adults
/ɑ/	[æ]	2/75 (3%)	0/48 (0%)
	[ɛ]	3/75 (4%)	0/48 (0%)
/ɛ/	[ɛ]	71/75 (95%)	45/48 (94%)
	[ɪ]	57/75 (76%)	30/48 (63%)
/o/	[ɔ]	71/75 (95%)	46/48 (96%)
	[u]	1/75 (1%)	0/48 (0%)
/u/	[ɔ]	3/75 (4%)	1/48 (2%)
	[u]	17/75 (23%)	10/48 (21%)
total		225/600 (38%)	132/384 (34%)

As can be observed in Table 2, substantial differences existed between the proportions of correct responses for the different target-substitution vowel pairs: $F(7, 280) = 282.940$, $p < 0.001$, $\eta p2 = 0.876$. There was no significant difference between the age groups: $F(1, 40) = 1.748$, $p = 0.194$, $\eta p2 = 0.042$. No interaction between Age Groups and VowelPair was observed: $F(7, 280) = 0.422$, $p = 0.889$, $\eta_p^2 = 0.010$.

Discussion

The results of Experiment 1, in which children and adults were asked to judge native Dutch words in which the vowel was either replaced by another instance of the Dutch vowel or by an English vowel, revealed that the behaviour of children and adults in this task was very similar. Children did not differ from adults in their acceptance of CPs: both groups accepted these in 98% of the cases, suggesting that the synthetic stimuli sounded natural to the listeners. Moreover, children and adults correctly rejected MPs in 63% and 66% of the cases, respectively.

With respect to the individual vowels, it was observed that there were considerable differences between the vowel pairs. Dutch words in which target /ɑ/ was replaced by English /ɛ/ or /æ/ were always rejected by the adults and accepted in only a few cases by the children. These vowels take clearly different positions in the vowel space, as shown in Figure 2, which presents a vowel plot with F1 and F2 values of the Dutch (circled, black) and English (grey) vowels in the stimuli.

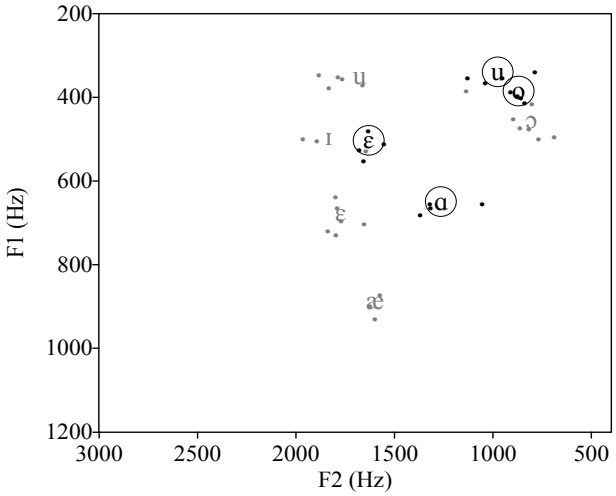


Figure 2. Vowel plot showing F1 and F2 values of the target Dutch (circled, black) and substituting English (grey) vowels in the stimuli. The symbols represent the mean values; the dots represent individual tokens.

By contrast, substitutions of Dutch /ɛ/ by English /ɛ/ or /ɪ/ were very frequently accepted by children and adults alike, with substitutions by /ɛ/ still more frequently accepted (95% by the children and 94% by the adults) than substitutions by /ɪ/ (76% and 63% by the children and adults, respectively). The very high acceptance rate of Dutch /ɛ/ words with the English /ɛ/ vowel inserted suggests that that the phonological representation for the vowel /ɛ/ may be shared in Dutch and English. That children and adults rejected substitutions by English /ɪ/ more frequently could be the result of the listeners' sensitivity to the /ɛ/-/ɪ/ contrast, which also occurs in Dutch.

Another type of substitution that was very frequently accepted was that of Dutch /o/ by English /ɔ/: children and adults accepted this type of substitution in 95% and 96% of the cases, respectively. As Figure 2 shows, Dutch /o/ and English /ɔ/ are very similar in spectral terms, leading to the hypothesis that they also have a shared phonological representation. Dutch /o/-words in which the vowel was replaced by English /u/ were not or hardly ever accepted by children and adults. The vowel plot in Figure 2 shows that the English /u/ is markedly more fronted than Dutch /o/, which would explain this pattern.

Finally, substitutions of Dutch /u/ by English /ɔ/ or /u/ were generally rejected. Substitutions by English /ɔ/ were accepted in only a few tokens; those in which Dutch /u/ was replaced by English /u/ were accepted in

23% and 21% of the cases by the children and adults, respectively. The low acceptance rate of the latter type of substitution can again by explained by the fronted character of the English /u/, which is in line with a general trend of u-fronting in British English.

In sum, the results of Experiment 1 show that children and adults do not differ from each other in their judgments on native Dutch words. They generally accept CPs and reject MPs in over 60% of the cases. A closer look at the individual vowels showed that specific vowel substitutions were accepted (e.g. Dutch /ɛ/-English /ɛ/ substitutions), while other were outright rejected (e.g. Dutch /ɑ/ - English /æ/ substitutions). In Experiment 2 it was investigated whether these patterns are directly mirrored by patterns in the listeners' L2s. In Experiment 2, participants are asked to judge English words containing English or Dutch vowels.

EXPERIMENT 2: ENGLISH WORDS WITH DUTCH VOWELS

Participants

All participants to Experiment 2 also performed Experiment 1.

Stimuli

The stimuli were based on 16 monosyllabic English words, in which the vowel was synthetically substituted either by the same English vowel, or by an acoustically similar Dutch vowel. The English words were selected on the basis of a vocabulary test taken by all participants (see Simon, Sjerps & Fikkert, 2013, for a description). The same bilingual Dutch-English speaker, who produced the Dutch words and English non-words in Experiment 1, also produced the English words and Dutch non-words in Experiment 2. As in Experiment 1, the stimuli were organised in three lists, presented in Table 3.

Table 3. List of stimuli in Experiment 2. Stimuli in bold present frames with the target English vowel synthetically inserted.

English vowel	English word	frame	List 1	List 2	List 3
/ɛ/	bed	/b_d/	**[bɛd]**	[bɛd]	[bɪd]
	ten	/t_n/	[tɪn]	**[tɛn]**	[tɛn]
	neck	/n_k/	[nɛk]	[nɪk]	**[nɛk]**
	pen	/p_n/	**[pɛn]**	**[pɛn]**	**[pɛn]**

Table 3 (cont.)

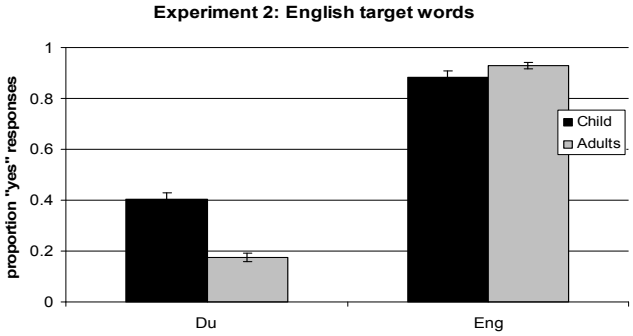
/æ/	cat	/k_t/	**[kæt]**	[kɛt]	[kɑt]
	rat	/r_t/	[rɑt]	**[ræt]**	[rɛt]
	hand	/h_nd/	[hɛnd]	[hɑnd]	**[hænd]**
	hat	/h_t/	**[hæt]**	**[hæt]**	**[hæt]**
/ɔ/	ball	/b_l/	**[bɔl]**	[bul]	[bol]
	four	/f_/	[fo]	**[fɔ]**	[fu]
	door	/d_/	[du]	[do]	**[dɔ]**
	fork	/f_k/	**[fɔk]**	**[fɔk]**	**[fɔk]**
/u/	moon	/m_n/	**[mun]**	[mun]	[myn]
	shoe	/ʃ_/	[ʃy]	**[ʃu]**	[ʃu]
	two	/t_/	[tu]	[ty]	**[tu]**
	fruit	/fr_t/	**[frut]**	**[frut]**	**[frut]**

Task and Procedure

The task and procedure were the same as in Experiment 1. The children performed Experiment 2 about 2-3 weeks after Experiment 1. The adults conducted the two experiments one after another, but completed an English questionnaire asking for basic background information in the time between the two experiments. This ensured that they switched to an English language mode before conducting Experiment 2.

Results

Figure 3 presents the 'yes' responses to English words that contained the Dutch vowels (two leftmost bars) or English vowels (two rightmost bars). In the left panel, proportion of 'yes' responses are displayed; in the right panel the reaction times.



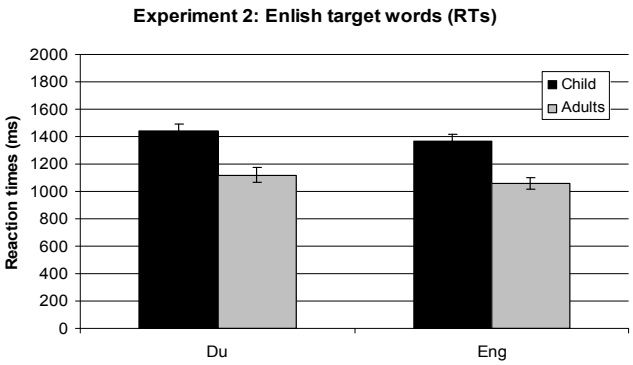


Figure 3. English task: Proportion of 'yes' responses (left panel) and RTs (measured from sound onset) with indication of the standard error of the mean.

Overall, adults gave more correct responses than children F (1,39) = 5.54, p = 0.024, η_p^2 = 0.124. Correct responses to CPs (English vowels) were significantly more frequent than correct responses to MPs (Dutch vowels): F (1,39) = 175, p = 0, η_p^2 = 0.818.. An interaction was observed between Stimulus Language and Age Group: F (1,39) = 21.1, p = 0, η_p^2 = 0.351. Post hoc comparisons show that the effect of Age is significant for the Dutch stimuli: F (1,39) = 40.67, p = 0, η_p^2 = 0.51. The effect is not significant for the English stimuli: F (1,39) = 1.3, p = 0.262, η_p^2 = 0.032. These findings shows that the young listeners are more inclined than the adults to accept Dutch vowels in English words as instances of English ones. However, the children are not more inclined to reject English words pronounced with an English vowel.

The analysis of the RTs revealed that participants responded faster to the stimuli with English vowels: F (1,39) = 4.22, p = 0.047, η_p^2 = 0.098. Adult participants were found to respond generally faster than children: F (1,39) = 27.98, p = 0, η_p^2 = 0.418. No significant interaction was observed between the factors Age Group and Stimulus Language: F (1,39) = 0.02, p = 0.893, η_p^2 = 0.

Table 4 displays the proportion of 'yes' responses for each of the Dutch substitution vowels.

Table 4. 'Yes' responses to English MPs by children and adults

target English V	substituting Dutch V	children	adults
/æ/	[ɛ]	32/75 (43%)	0/48 (0%)
	[ɑ]	20/75 (27%)	2/48 (4%)

Table 4 (cont.)

/ɛ/	[ɛ]	42/75 (56%)	13/48 (27%)
	[ɪ]	15/75 (20%)	0/48 (0%)
/ɔ/	[o]	43/75 (57%)	37/48 (77%)
	[u]	0/75 (0%)	0/48 (0%)
/u/	[y]	40/75 (53%)	8/48 (17%)
	[u]	50/75 (67%)	7/48 (15%)
total		242/600 (40%)	67/384 (17%)

Substantial differences existed between the proportions of 'yes' responses for the different target-replacement vowel pairs: $F(7, 273) = 32.463$, $p < 0.001$, $\eta_p^2 = 0.454$. The adults performed significantly better than the children: $F(1, 39) = 38.633$, $p < 0.001$, $\eta_p^2 = 498$. These effects were accompanied by an interaction between VowelPair and AgeGroup: $F(7, 273) = 9.350$, $p < 0.001$, $\eta_p^2 = 0.193$.

DISCUSSION

The results of Experiment 2, in which native Dutch listeners were asked to judge the correctness of English words in which the vowel was either the target English vowel or a Dutch vowel, revealed that children did not differ from adults in their acceptance of English words presented with the target English vowel. By contrast, they did differ from the adults in their judgements of English words with a Dutch vowel inserted, in that they more frequently than adults accepted such mispronunciations.

With respect to individual vowel substitutions, it could be observed that substitutions of English /æ/ by Dutch /ɛ/ and /ɑ/ were not or hardly ever accepted by the adults, but received much higher proportions of 'yes' responses by the children. English /æ/-words realized with a Dutch /ɛ/ were accepted in 43% of the cases by the children, while the adults did not accept any of these words. This suggests that the adults had created a new category for the English vowel /æ/, while the children were using an underspecified category which included both realizations with [ɛ] and [æ].

Substitutions of English /ɛ/ by Dutch /ɛ/ were accepted in 56% and 27% of the cases by the children and adults, respectively. It is surprising that the listeners still rejected these words in a substantial number of cases, since Dutch and English /ɛ/ are acoustically very close, as shown in Figure 4. English /ɛ/-words in which the vowel was replaced by Dutch /ɪ/ were accepted in only 20% of the tokens by the children and in none of the

tokens by the adults, confirming that Dutch listeners are sensitive to this contrast from their native language.

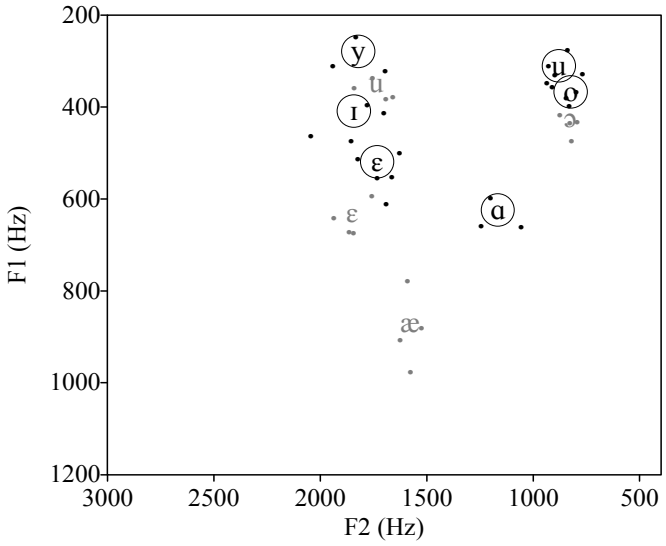


Figure 4. Vowel plot showing F1 and F2 values of the target English (grey) and substituting Dutch (circled, black) vowels in the stimuli. The symbols represent the mean values; the dots represent individual tokens.

Substitutions of English /ɔ/ by Dutch /o/ were frequently accepted by the children (57%), but even more by the adults (77%). We do not as yet have a good explanation for this pattern. Substitutions of /ɔ/ by Dutch /u/ were rejected in all cases by both listener groups.

Finally, English words in which the vowel /u/ was replaced by Dutch /y/ or /u/ were again accepted more frequently by the children than by the adults. The fronted character of English /u/ explains why substitutions by the Dutch front vowel /y/ were often accepted, as Dutch /y/ and English /u/ are then acoustically very close (see Figure 4).

In sum, the results of the English task showed that children's familiarity with the English words and vowels was sufficiently high to accept by far the majority of CPs (89%) and to reject MPs involving Dutch vowels which are considerably different from the English target vowels in acoustic terms (e.g. substitution of /ɔ/ by /u/). However, when the vowels do not differ greatly in terms of F1 and F2, children fail to reject English words with Dutch vowels inserted. These data show that children were less sensitive to English phonemic contrasts in all of the vowels considered.

GENERAL DISCUSSION

The experiments were set up to test the development of phonological vowel representations in school-aged child second language learners. Children and a control group of adults were asked to judge Dutch words in which Dutch or English vowels were synthetically inserted (Experiment 1) or English words with English or Dutch vowels inserted (Experiment 2).

With respect to the native language, the results of the Dutch experiment revealed that children and adults did not differ in their judgments on native Dutch words with either Dutch or English vowels inserted. This suggests that 9-12-year old children have well-established categories for their native vowels, and confirms the findings reported in Simon, Sjerps and Fikkert (2013). Both children and adults were very tolerant with respect to certain vowel substitutions, while they outright rejected others. An explanation was sought in the acoustic distance between the vowels. Both children and adults seemed to be sensitive to even small acoustic differences. For instance, English /ɔ/ was only slightly closer to Dutch /o/ than to Dutch /u/ in terms of F1 and F2 in the stimuli, yet Dutch /o/-words realized with English [ɔ] were rejected in only 5.1% and 4.2% of the tokens by the children and adults, respectively, while Dutch /u/-words realized with English [ɔ] were rejected in 96.2% and 97.9% of the tokens. However, acoustic distance alone does not offer an explanation for all patterns. Rather, the native phonology also seems to play an important role in the setting of vowel category boundaries. For instance, Dutch /ɛ/ was acoustically closer to English /ɪ/ than to English /ɛ/ in terms of F1, and only marginally further away in terms of F2, yet realizations of Dutch /ɛ/ words with English [ɪ] were more often rejected than realizations with English [ɛ]. The native phonology offers an explanation here: since Dutch has a contrast between the phonemes /ɛ/ and /ɪ/, Dutch listeners map English [ɪ] realizations to their native Dutch /ɪ/ phoneme and hence reject Dutch words realized with English [ɪ].

Whereas children and adults did not differ with respect to their judgments on native Dutch words, they did differ in their responses to English words, at least when a native Dutch vowel was inserted. Overall, children and adults did not differ in their judgments on English words with English vowels, which they accepted in by far the majority of tokens (over 88%). The most important difference between children and adults was observed in the responses to English words in which a Dutch vowel

was inserted, in that the adults rejected significantly more of these words than the children. Whereas some vowel substitutions were detected (and rejected) by both groups, such as the realizations of English /ɔ/-words (like 'ball') with Dutch /u/, others were rejected by the adults, but accepted by the children. One such vowel was English /æ/. As mentioned above, the adult listeners had clearly created a new phonological representation for this vowel, as they rejected all instances of English words in which target /æ/ was replaced by Dutch /ɛ/. Some children, by contrast, had not (yet) created a separate phonological category for English /æ/ and accepted a native Dutch vowel, /ɛ/ or /ɑ/, as a substitution. This shows that for these children the phonological representations of the native language interfere with the non-native phonological component. As predicted by Flege's Speech Learning Model (1997), the results also confirm that, as proficiency in the non-native language increases, the boundaries between phonological categories become sharper.

CONCLUSIONS

We reported on the phonological development in the native and non-native language of a group of 9-12-year-old Dutch-speaking children learning English, and compared the children's development to that of more proficient non-native adults. The aim was to examine to what extent children had built separate phonological vowel representations in the native and non-native language and identify which criteria children used to decide on the category membership of native and non-native vowels. The results confirm those in Simon, Sjerps and Fikkert (2013) that at that age children have well-established phonological vowel categories in their native language. However, in the non-native language, children tend to accept mispronounced items which involve sounds from their native language. At the same time, however, they do not seem to fully rely on their native phonemic inventory because the children accepted most of the correctly pronounced English items.

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