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Phonetic learning is not enhanced by sequential exposure to more than one language*

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Choi, Jiyoun, Mirjam Broersma, and Anne Cutler. 2018. Phonetic learning is not enhanced by sequential exposure to more than one language. *Linguistic Research* 35(3), 567-581. Several studies have documented that international adoptees, who in early years have experienced a change from a language used in their birth country to a new language in an adoptive country, benefit from the limited early exposure to the birth language when relearning that language's sounds later in life. The adoptees' relearning advantages have been argued to be conferred by lasting birth-language knowledge obtained from the early exposure. However, it is also plausible to assume that the advantages may arise from adoptees' superior ability to learn language sounds in general, as a result of their unusual linguistic experience, i.e., exposure to multiple languages in sequence early in life. If this is the case, then the adoptees' relearning benefits should generalize to previously unheard language sounds, rather than be limited to their birth-language sounds. In the present study, adult Korean adoptees in the Netherlands and matched Dutch-native controls were trained on identifying a Japanese length distinction to which they had never been exposed before. The adoptees and Dutch controls did not differ on any test carried out before, during, or after the training, indicating that observed adoptee advantages for birth-language relearning do not generalize to novel, previously unheard language sounds. The finding thus fails to support the suggestion that birth-language relearning advantages may arise from enhanced ability to learn language sounds in general conferred by early experience in multiple languages. Rather, our finding supports the original contention that such advantages involve memory traces obtained before adoption. **(Sookmyung Women's University · Max Planck Institute for Psycholinguistics · Radboud University · Western Sydney University)**

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1. Introduction

Language experience can leave long-lasting traces, even without any awareness on the part of language users. This is, for instance, the case with international adoptees, whose first exposure to the language of the country they are born in may be replaced at an early age by exposure to a completely different and probably unrelated language in their country of adoption. The newly encountered language becomes their effective mother tongue, and their birth language is apparently forgotten, as many studies have conclusively demonstrated (Pallier et al. 2003; Ventureyra et al. 2004).

Many years later, however, the existence of the traces laid down in that very early experience can show itself on exposure to the long-unused birth language. For instance, the brain responds to heard birth-language input in the way that a native user's brain responds, not the way a brain without previous exposure responds (Pierce et al. 2014). Also, learning to identify the birth-language sounds proves easier for adoptees than for matched control participants (Choi et al. 2017a; Choi et al. 2017b).

The precise nature of the difference found in such studies can however be debated. The undeniable advantage displayed by the adoptees in such studies could be due to memory traces, as generally argued, but it could (either instead, or as well) rest on an advantage of a more general nature. That is, rather than an effect specific to the birth language, the advantage could involve linguistic processing in general.

There are arguably many types of advantage that could accrue from early exposure to more than one language. Relatively few studies have been carried out with international adoptees, but some relevant findings concerning such an advantage are to be found in studies of children raised bilingually rather than monolingually. Bilingual families typically expose children to more than a single language at once, of course; this is different from the experience of our adoptee participants who received exposure to their birth language and their adoptive language in sequential order instead. Nonetheless, if experience with more than one language is the key factor, then such findings are of relevance.

Simple discrimination tasks – just telling the difference between sound A and sound B, for example – do not show advantages on the part of listeners who have had exposure to more than one language. This is true for a task in which pairs of sounds from one language are interspersed with pairs of sounds from another language, and listeners are asked to detect such language switches; adult listeners who are monolingual, bilingual or trilingual perform equivalently in such a procedure (Werker 1986). Likewise, a simple same-different discrimination of Korean phonemes was not performed better by adults who were bilingual in languages without such distinctions, compared with monolinguals (Patihis et al. 2015). Ventureyra et al. (2004), mentioned above, failed to find evidence of better performance by Korean-born adoptees than control listeners for Korean phoneme perception, but used only a discrimination task; and our own group of adoptees and their matched control participants likewise showed no difference in carrying out such simple discriminations, involving either Korean (the birth language) or Japanese sounds (Choi et al. 2015). Phonetic discrimination appears to be too easy a task for significant differences in cross-group performance to be detected.

On other levels of linguistic performance, however, bi- or multilinguals do outperform monolinguals. Word-learning tasks, in which nonsense forms must be paired with some meaning, show such effects (Antoniou et al. 2015; Kaushanskaya and Marian 2009), for instance. Discrimination at a sentence level, based on prosodic structures, is performed better by bilingual children, and by children with musical training, than by monolingual children with no musical experience (Stepanov et al. 2018). Voice change detection is also facilitated by bilingualism (Levi 2018).

Note that it is not surprising to find prosodic and talker discrimination patterning together; this is also the case across a range of effects concerning speech perception, especially when a particular type of speech sound has processing priority. Thus in general, lexical-level tasks typically show advantages when consonant processing is involved (so, for instance, masking consonants exercises more impact on word recognition than masking vowels does), while vowels carry talker and prosodic information and are in the advantage when processing of these is required (masking vowels has more impact on recognition of talkers or emotion than masking of consonants does; Nazzi and Cutler 2019). However, this speech sound asymmetry appears, as would be expected, to be the same across languages and to be quite independent of the number of languages known by listeners. The word-learning tasks, in contrast, show the strongest evidence of an advantage conferred by knowing more than one language.

There is to our knowledge just one study which has addressed learning at a phonological rather than lexical level and shown such an advantage. In this study, by Tremblay and Sabourin (2012), young adults who were monolingual in English, bilingual in French and English, or multilingual in English, French and one other language, were trained to distinguish Hindi stop consonant contrasts that are known to be difficult for listeners of English and French. At a pretest stage there was no differences between the groups. Over the following ten days, the training was administered in three sessions. After the final training, the groups were given a post-test, which revealed that, though all groups had shown improvement, the monolingual group had learned significantly less than the two groups with more than one language. Tremblay and Sabourin ascribed the difference to enhancement of linguistic (in this case phonetic) learning ability as a consequence of exposure to more than one phonetic system. This is a different explanation than the one proposed (and disconfirmed) by Werker (1986) and others for the case of phonetic discrimination; here the advantage is localised in the learning process rather than at the level of phonetic perception. The learning account has the additional plausibility that it links with the lexical-level results described earlier (Antoniou et al. 2015; Kaushanskaya and Marian 2009).

If this explanation is correct, and if the sequential multilingual exposure received by adoptees is in this respect equivalent to bi- or multilingualism, then we would expect that such adoptees would also be able to perform better than control participants in learning a new and difficult phonetic contrast. This is the proposal that we set out to test in the present experiment, with the contrast in question being a durational contrast in Japanese; none of the participants in our study had been exposed to Japanese, and the contrast in question is known to be difficult for speakers of our participants' adoptive language (Sadakata and McQueen 2013).

2. Methods

2.1 Participants

There were two groups of participants. The first group was twenty-nine Dutch-speaking Korean adoptees in the Netherlands (twenty-one females, eight males, aged 23-41 years, M = 32 years). The age of the adoptees when adopted by Dutch-speaking families ranged from 3 to 70 months (i.e., 5 years and 10 months, henceforth 5:10), with an average age of 23 months (1:11). Fourteen participants were adopted before the age of 6 months (range 3-5 months, M = 4 months), and the other fifteen participants were adopted after the age of 17 months (range 1:5-5:10, M = 3:3). Length of residence in the Netherlands ranged from 23 to 40 years, with an average length of 30:10. None had previous exposure to Japanese or had learned Korean after adoption.

The second group was twenty-nine Dutch control participants (sixteen females, thirteen males, aged 19-47 years, M = 32 years). They had no previous exposure to Japanese and no experience in learning Korean. The controls were matched as closely as possible to the adoptees on four factors that might potentially affect learning in general: (1) age at testing, (2) sex, (3) number of languages participants knew, even if only a little (adoptees, M = 2.8; controls, M = 2.6), and (4) highest level of schooling completed among the four levels in the Dutch high school system (from lowest to highest, VBO, MAVO, HAVO, and VWO[1]; for adoptees, 2 VBO, 8 MAVO, 9 HAVO, 10 VWO; for Dutch controls, 2 VBO, 7 MAVO, 5 HAVO, 15 VWO). The adoptee and control groups did not significantly differ in any of the factors (all p values > .10).

The participants were recruited through the Dutch Association for Korean

1 Dutch children enter high school after eight years of elementary education, when they are approximately 12 years old. There are different types of high schools, which differ in level and duration, and prepare for different types of tertiary education. The choice for a school type is based on the recommendation of the elementary school, informed by the outcome of formal tests. The relevant school types in this study were: VBO (*'Voorbereidend BeroepsOnderwijs'*, literally 'preparatory applied education'), pre-vocational education, 4 grades; MAVO (*'Middelbaar Algemeen Voortgezet Onderwijs'*, 'middle-level general continued education'), 4 grades; HAVO (*'Hoger Algemeen Voortgezet Onderwijs'*, 'higher general continued education'), 5 grades, gives access to universities of applied sciences; VWO (*'Voorbereidend Wetenschappelijk Onderwijs'*, 'preparatory scholarly education'), pre-university education, 6 grades, gives access to universities.

Adoptees Arierang, word of mouth, or through the Max Planck Institute for Psycholinguistics participant pool. They were paid for participation.

2.2 Training stimuli

Three length patterns were modeled on Japanese vowel and consonant length contrasts. The patterns consisted of (1) a short vowel plus a short consonant (henceforth Singleton), (2) a short vowel plus a long consonant (henceforth Geminate), (3) a long vowel plus a short consonant (henceforth Long Vowel). Twenty-five triplets (i.e., Singleton-Geminate-Long Vowel combinations) of disyllabic VCV (V: vowel, C: consonant) pseudowords were created, e.g., [eɸu]-[eɸ:u]-[e:ɸu]. The consonant was always voiceless bilabial fricatives [ɸ] (which occur as an allophone of voiceless glottal fricatives [h] and as a marginal phoneme in loan words in Japanese). The vowels [a], [e], [i], [o], and [u] were exhaustively combined in the first and second vowel position.

Five male and five female native speakers of Japanese (either Standard Japanese or West dialect, aged 28-47 years) recorded multiple tokens of all seventy-five items (twenty-five triplets). The speakers read the items one by one in a clear citation style, in a soundproof booth with a Sennheiser microphone. The recording was digitized using a computer at a sampling rate of 44 kHz. The tokens were excised from the recording with the speech editor PRAAT. One token of each item was selected for each speaker for training. One additional token of two triplets was selected from one of the male speakers to use for instructions.

2.3 Test stimuli

The same twenty-five triplets as in the training were recorded by a new female native speaker of Japanese (West dialect, 34 years of age). One token for each of the seventy-five items was selected for the tests.

2.4 Procedure

Adoptees and Dutch controls completed thirteen training blocks and three tests over 10-12 days (11 days for 90% of cases). The three tests were a pre-test before the training, a midway test after the four training blocks, and a final test after the whole training. Training and testing were carried out in a quiet room at a location chosen by the participants, such as a home or workplace. During that period, the experimenter (the first author) visited participants four times with a mean interval of 2.3 days. On these visits, seven training blocks and the three tests were carried out, and the remaining six training blocks were completed as homework with equipment (laptop and headphones) provided to them by the experimenter, in the intervals between the visits. Table 1 shows the detailed schedule for training and testing.

In all training and testing, participants sat in front of a laptop. They heard materials through high quality headphones and responded to tasks by pressing keys on the laptop keyboard. Presentation software (from the 14 series, Neurobehavioral Systems Inc.) was used for constructing and running the experiment. Each training block lasted about 8 minutes and each test about 5 minutes.

Table 1. Schedule for training and testing over 11 days

Day	Visit	Activity (in chronological order)		
1	1st visit	pre-test,	training 1	
2, 3		training 2,	training 3	
4	2nd visit	training 4,	midway test,	training 5
5, 6, 7		training 6,	training 7	
8	3rd visit	training 8,	training 9	
9, 10		training 10,	training 11	
11	4th visit	training 12,	training 13,	final test

2.5 Training task

A three-alternative forced-choice identification task was used. Each training block began with instructions. Participants were instructed that they should listen carefully to each stimulus and categorize it into one of three categories using response keys on the computer keyboard: '^' for Singleton, '&' for Long Vowel, '*' for Geminate targets. To inform participants which response keys corresponded to each sound category, two triplets were presented twice while the symbol (^, &, *) corresponding to each sound was simultaneously highlighted on the computer screen.

A training trial began with a fixation mark for 400 ms followed by a blank screen for 400 ms. One auditory stimulus was then played and participants responded by pressing one of the response keys. Feedback on the correctness of the responses was provided: for a correct response, the Dutch word for "good" was presented on the screen in green; for an incorrect response, the Dutch sentence for "the correct answer is:" was presented in red with the correct answer. These was no time-out for responses. Six practice trials were given prior to the main training.

Each training block consisted of seventy-five trials with seventy-five tokens. Each of the first 10 blocks contained stimuli from a single speaker. To increase variety for the listeners and make the task more challenging as the end of training approached, the last three blocks contained stimuli from multiple speakers: 11^{th} block from the five female, 12^{th} block from the five male, and 13^{th} block from all ten speakers. The order of speakers was fixed across participants, but the order of the seventy-five stimuli in each block was randomized.

2.6. Test task

This task was identical to that for the training, except that no feedback was provided.

3. Results

3.1 Identification accuracy

Repeated-measures ANOVAs were conducted on arcsine-transformed proportion of correct responses, with the between-subject factor Group (adoptee, Dutch control), and the within-subject factors Test (pre-test, midway test, final test) and Target type (Singleton, Geminate, Long Vowel). Responses longer than 10 s were excluded from analysis (27 trials; 0.2% of data). A p value smaller than 0.05 was considered as significant.

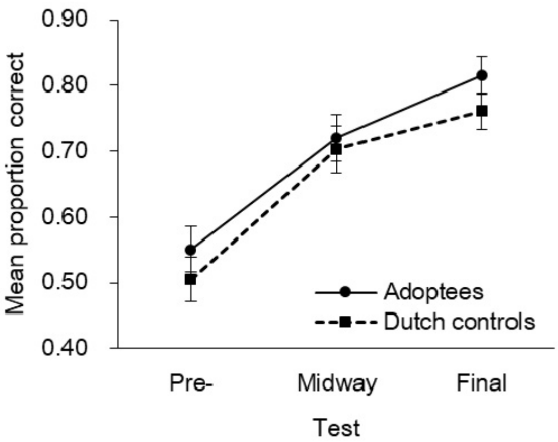

Figure 1. Mean proportion correct for adoptees and Dutch controls at pretest, midway, and final test. Error bars show standard errors

As Figure 1 shows, adoptees and Dutch controls improved across training, and they performed similarly on all tests. ANOVAs, as expected, showed a significant main effect of Test (F(2,112)=81.3, *p*<.001): follow-up analysis showed that adoptees and Dutch controls significantly improved from pre- to midway test (adoptee: F(1,28)=22.3, *p*<.001; Dutch control: F(1,28)=43.5, *p*<.001), and from midway to final test (adoptee: F(1,2)8=13.5, *p*<.01; Dutch control: F(1,28)=7.2, *p*<.05). Importantly, however, there was no main effect of Group and there were no significant interactions between Group and Test, or between Group, Test, and Target: planned comparisons confirmed that the groups did not significantly differ on any test.

The Target effect was significant, revealing that the Geminate targets received the fewest correct responses, the Long Vowel the most, and the Singleton received in-between correct responses (see Table 2; Geminate vs. Singleton: F(1,56)=19.3, *p*<.001; Geminate vs. Long Vowel: F(1,56)=95.8, *p*<.001; Singleton vs. Long Vowel: F(1,56)=30.5, *p*<.001). Target and Group interacted (F(2,112)=5.2, *p*<.01), but follow-up analysis showed no significant group differences on any target type.

Table 2. Mean proportion correct (and standard error) for three target types

	Adoptees	Dutch controls	Overall
Geminate	0.64 (0.03)	0.54 (0.03)	0.59 (0.02)
Singleton	0.66 (0.03)	0.68 (0.03)	0.67 (0.02)
Long Vowel	0.78 (0.03)	0.74 (0.03)	0.76 (0.02)

3.2 Effect of age at adoption

Correlations were computed between age at adoption and adoptees' (arcsine-transformed) proportion correct on each test. Prior to carrying out the correlations, it was examined whether the age at adoption correlated with any control factor. The age at adoption was significantly correlated with age at testing (r=.59, $p<.01$) and with sex ($t_{27}=3.38$, $p<.01$): that is, individuals who were adopted earlier were younger at the time of testing and were more likely to be female. Controlling for these two factors, partial correlations were computed. Results showed no significant correlations between the age at adoption and adoptees' performance on any test.

We further examined a potential effect of adoption age by comparing the fourteen adoptees who were adopted before their age of 6 months (early adopted subgroup) to the fifteen adoptees adopted after the age of 17 months (later adopted subgroup). As noted, the subgroups differed in age at testing and sex such that the early adopted subgroup was younger (28 vs. 35 years, $p<.001$) and had a higher proportion of females (13/14 vs. 8/15, $p<.05$) than the later adopted subgroup. Controlling for the two factors, analysis of covariance (ANCOVA) was performed with the within-subject factors Test, Target type, and the new between-subject factor Adoption age (early adopted, later adopted). Results showed no significant effect of Adoption age and no interactions with Adoption age.

4. Discussion

Korean adoptees in the Netherlands and Dutch control participants were trained on the perception of a Japanese length contrast that they had not been exposed to before. The results showed that the adoptees did not outperform the controls on the Japanese sound learning: the two groups performed similarly on all identification tests undertaken before, during, and after the perception training.

As reported elsewhere, the same Korean adoptees and control participants were trained on the perception of Korean stop consonants (simultaneously with the present training on the Japanese sounds). In contrast to the results here, the adoptees showed clear advantages over the controls on learning Korean sounds: the adoptees significantly outperformed the controls at identifying the Korean fortis, lenis and aspirated stops after the training while there was no group difference before the training (Choi et al. 2017b). The relearning benefit was further found in a production domain, such that native listeners of Korean more accurately identified the adoptees' productions of the Korean stops than the sounds produced by the control participants (Choi et al. 2017a). These findings are in line with other studies providing behavioural and neural evidence for adoptee advantages for processing their birth-language sound contrasts (Oh et al. 2010; Pierce et al. 2014). Taken together, previous studies clearly show that linguistic knowledge that had been acquired in early months can be retained without continual use of the language for decades and that these knowledge traces confer relearning benefits for the birth language later in life.

In a control study we had earlier shown that the adoptee benefit was not due to early exposure to more than one language creating an enhanced ability to perceive or distinguish unfamiliar language input. Just as studies comparing bilinguals to monolinguals had found no evidence that multilingual exposure produces enhanced ability at this simple processing level (Patihis et al. 2015; Werker 1986), our adoptee and control participants also performed equivalently in discrimination tasks (Choi et al. 2015).

The present study adds to this a failure of the factor age of adoption to affect the adoptees' learning of the Japanese sounds. When the same adoptees learned the Korean sounds, likewise, the age at adoption did not affect their performance; although the relearning benefit might have been expected to be larger for participants with longer early exposure to Korean (and thus an older age at adoption), no significant correlations between adoption age and relearning benefits were observed, and there were also no differences between early- versus later-adopted individuals (Choi et al. 2017a; Choi et al. 2017b). It is in principle possible that the lack of effect in the Korean sound learning could have arisen from the early-adopted individuals happening by chance to be better at sound learning in general than the later-adopted individuals, thus cancelling out an experiential advantage for the latter group. The finding in the present study, however, rules out this possibility, given that the same early- and later-adopted individuals also did not differ in their learning of the novel (Japanese) sounds where previous experience was not at issue.

The present results further exclude another potential factor that might affect adoptee versus control performance, namely the adoptees' attitude to participation in birth-language training study. It seems plausible to assume that adoptees might have a favorable attitude toward participation in their birth-language training, which might lead them to outperform control learners. Our outcome, however, does not support this suggestion, as evidenced by similar performance between the adoptees and the controls even though all participants may well have thought that the Japanese sounds were Korean (the adoptees' birth language). The results thus suggest that the adoptees' relearning benefit for their birth-language contrasts reported so far seem to be best explained in terms of an account of the lasting birth-language knowledge acquired before adoption.

For bilinguals, another proposal has been made concerning later advantage. This concerns learning, which seems to be enhanced by earlier exposure to more than one language, both for lexical-level learning (Antoniou et al. 2015; Kaushanskaya and Marian 2009) and for phonetic-level learning (Tremblay and Sabourin 2012). Our present results show no sign of such an effect for adoptees. Learning their birth language succeeded significantly better in their case than in the case of their control co-participants (Choi et al. 2017a; Choi et al. 2017b); but in learning a difficult contrast of a previously unencountered language their differing experience gave them no help at all in comparison to the same controls.

There are two conclusions that may be drawn here. One is that the adoptee experience of exposure first to one language, then to a subsequent replacement language, does not induce a generally enhanced ability to learn any language in which later input is provided. The accepted account of adoptees' superior performance in re-learning their birth language sounds is that knowledge of the contrasts involved had been stored early on and could be tapped when the relearning situation arose; that account is further supported by the present findings.

But in that case, another conclusion must be drawn in consequence, for the literature shows that bilingualism (and multilingualism) does indeed prompt better learning of later-encountered novel language input. Adoptees, we must conclude, do not benefit from the advantages conferred by bilingualism. This is entirely explicable, since the bilingual experience involves a substantial cognitive load incurred by the need to keep the languages in question apart (Abutalebi and Green 2008; Hernandez et al. 2001; Rodriguez-Fornells et al. 2002). Adoptees never face such a separation task; their language experience is not bilingualism, but may rather be termed sequential monolingualism. Thus the simple exposure at differing times to multiple linguistic systems confers no advantage in itself; the linguistic learning advantage of bilinguals as found by Kaushanskaya and Marian (2009), Antoniou et al. (2015) and Tremblay and Sabourin (2012) seems to be yet another effect of the executive control advantage that has been ascribed to the need to keep more than one linguistic system apart when they are in use at once (Barac et al. 2016; Bialystok and Martin 2004; Hernández et al. 2010). The adoptee advantage in studies such as ours (Choi et al. 2017a; Choi et al. 2017b) is one of memory, not of superior processing skill; and sequential monolingualism does not amount to bilingualism.

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