Rediscovering a forgotten language

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Rediscovering a forgotten language

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1. Introduction

Internationally adopted children go through a major change early in life. After some time in their country of birth, they move to another country, far from their roots. This obviously requires substantial adaptation, to a new culture, a new way of living, and a new family. The ease with which this transition is made depends on many things, including the experiences the child has had in the birth country, experiences around the adoption, and the child's age at the time of adoption (Clark & Hanisee, 1982; Rutter, 1998; Wickes & Slate, 1996). In the Netherlands, adoption usually occurs before six years (but in exceptional cases later:[1] Adoption Services Foundation, 2013).

One of the major adaptations that internationally adopted children must make is, in most cases, that to a new language. After being exposed to their birth language for some time they experience a sudden cut-off in this exposure. The language they know, or are in the process of acquiring, suddenly loses its communicative value. At the same time, they are exposed to a new language that they need to start learning. This change is much more abrupt for international adoptees than for children who migrate with their families, because the latter will usually still be able to use the childhood language with their family, even if the language is not spoken in their new environment.

[1] According to the *Convention on Protection of Children and Co-operation in Respect of Intercountry Adoption* formulated by the Hague Conference on Private International Law, the maximum age at which a child can be internationally adopted is six years in the Netherlands, unless the child is adopted together with a sibling, which can be a reason to extend the maximum age (Adoption Services Foundation, 2013)

The speed with which international adoptees acquire the language of their new environment depends in the first place on their age, and there is also substantial inter-individual variation (Roberts et al., 2005; Scott, Roberts, & Krakow, 2008) The common experience is that adoptees generally learn the language of their new environment very rapidly, catching up with their age-matched, non-adopted peers usually within two years after adoption (Clark & Hanisee, 1982; Roberts et al., 2005), to the extent that they master the language at a level of proficiency which is indistinguishable from their peers.[2] Adoptees commonly report that they consider their new language as their "first language", and in the literature about this population, the language is therefore sometimes referred to as the "second first language" rather than the second language (Roberts et al., 2005; Scott et al., 2008).

Around the time they acquire the language of their new environment, international adoptees generally stop using their birth language. Case studies show that adopted children soon stop using — and may indeed rapidly forget — the words of their birth language (Isurin, 2000; Nicoladis & Grabois, 2002). By the time they reach adulthood, international adoptees commonly report that they do not remember their birth language at all (Pallier et al., 2003; Ventureyra, Pallier, & Yoo, 2004). Thus, international adoptees might effectively become monolinguals[3] of the language which is used in their new environment. This raises the question whether international adoptees completely forget their birth language indeed, or whether the language still slumbers in their memory, unnoticed. This question remains unanswered by previous studies, and is the topic of this dissertation. The present study investigates the existence of long-lasting knowledge of birth-language phonology in

[2] Some studies even find that by that time, adoptees' proficiency is *better* than that of their non-adopted peers; see Chapter 1.1

[3] Leaving any other second or foreign languages out of consideration.

international adoptees, by testing Korean adoptees in the Netherlands by the time they have become adults.

1.1 Development of the language of the new environment in international adoptees

The rapidity with which internationally adopted children usually acquire the language of their new environment has been well documented. Language acquisition seems to begin immediately after adoption, as evidenced by a case study carried out on a Chinese adoptee in Canada, who was adopted by an English-speaking family at the age of 17 months (Nicoladis & Grabois, 2002). After only six weeks in Canada, she could already understand and produce several English words. Another case study where a nine-year-old Russian adoptee in the USA was observed showed that in a picture naming task in English, the adoptee could already produce about 40 % of the tested words after four months in the USA, and about 80 % of the tested words after eight months in the USA (Isurin, 2000).

In line with those case studies, it has been shown that lexical development during the early stage of acquisition is generally faster for adopted children learning a "second first language" than for monolingual infants acquiring their first language (Geren, Snedeker, & Ax, 2005; Snedeker, Geren, & Shafto, 2007). After only three months of exposure to English, adoptees (between three and six years old) obtained an average English vocabulary size that was comparable with that for two-year-old English children, and this fast lexical development continued to be observed until at least a year after adoption.

Apart from the remarkably fast acquisition, the adoptees in these studies progressed through the same developmental patterns as monolingual infants typically do (Geren et al., 2005; Snedeker et al., 2007). As infants do in their native language, the adoptees started by building a lexicon that comprised a large proportion of nouns, and as vocabulary size

increased, the proportion of verbs and closed-class items increased. Also, adoptees' syntactic development followed the pattern commonly observed for infants acquiring their first language, such that the adoptees used more complex utterances including function words as their vocabulary size increased.

Eventually, adopted children typically catch up with their non-adopted peers. No differences were found between adoptees and their monolingual peers after approximately two years of exposure to the new language (Clark & Hanisee, 1982; Roberts et al., 2005). Roberts et al. (2005) assessed the English language skills of children of three to six years old who were adopted from China into English-speaking families, two years or longer after adoption. Comprehension, production, and articulation accuracy for English vocabulary were assessed with standardized measures. The results showed that a large majority of the adoptees scored within or even above the average range for the normative sample in all measures. Similarly, Clark & Hanisee (1982) have demonstrated that after approximately two years or longer in the USA, preschoolers who were adopted from Asia outperformed their monolingual peers on a measure of English vocabulary comprehension. (Note that the finding that the adoptees outperformed the non-adoptees might be an artifact of the method used. In both studies, performance of international adoptees was compared to the norms based on a large sample of non-adopted children, who did not take part in the same study. Therefore, there may have been differences in other variables between the adoptees and the normative group, such as socio-economic status of the families, which might explain the difference.)

Scott et al. (2008) explored oral and written language skills in seven- to nine-year-old adoptees with diverse standardized measures as well as narrative language samples from each child. The results showed, again, that the adoptees' language skills met or exceeded the age-appropriate range, indicating that the adoptees' subsequent acquisition after catching up with their monolingual peers stayed robust.

Note that there is some evidence that adoptees might have difficulties in specific aspects of language use. Dalen (1999) found that adolescent adoptees had more difficulty understanding abstract language (e.g., classroom lectures in which context of situation and non-verbal cues are limited) than non-adopted peers. Nevertheless, the general picture emerging from the studies above is that adoptees soon catch up and subsequently keep up with their monolingual peers in the language of their new environment.

1.2 First language phonological development in the first months of life

What can international adoptees be expected to know about their birth language by the time they are adopted?

Infants, who are excellent language learners, begin acquiring the birth language very early — even in the womb — by listening to it. Although infants are able to speak words by the time they are about a year old on average, which is obvious evidence of knowledge about the birth language, they have been absorbing information about the birth language all through the first months of life.

Infants substantially acquire the phonology of their native language during the second half of their first year. This is evidenced by a decline in sensitivity to non-native phonemic contrasts as well as an increased sensitivity to native-language contrasts. That is, young infants begin with an ability to discriminate both native and non-native phoneme contrasts (Eimas, Siqueland, Jusczyk, & Vigorito, 1971; Streeter, 1976), but as a function of experience in the birth language, their ability to discriminate non-native contrasts becomes weak. They thus become more like adult listeners, with a lower sensitivity to foreign-language contrasts than to native contrasts. For instance, English-learning infants aged between six and eight months could discriminate non-native Hindi and Thompson consonant contrasts, but infants aged between 10 and 12 months could no longer discriminate the contrasts: adult English

listeners likewise could not discriminate the contrasts (Werker & Tees, 1984). In a longitudinal study, Finnish infants showed improvement in discriminating a native Finnish vowel contrast between six and 12 months of age, whereas their ability to discriminate a non-native Estonian vowel contrast became weaker (Cheour et al., 1998). Similarly, English-learning infants' ability to discriminate English consonant contrasts improved between the ages of seven and 11 months (Rivera-Gaxiola, Silva-Pereyra, & Kuhl, 2005). In sum, at approximately six months of age, infants begin to show evidence of having acquired knowledge about the native phoneme inventory (Kuhl, 2004; Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992), and their phoneme perception becomes further adjusted to the native language in the second half of the first year (for a review, see Kuhl, 2004).

It is not clear what infants already know about the phonology of the native language before the age of six months. Even though there is no evidence that children under six months of age have tuned into the sounds of the native language, this does not necessarily mean that they have no knowledge about the native phonemes. It seems likely that if infants show knowledge of native phonemes at the age of six months, the process of learning leading up to this knowledge might have started earlier than at six months. Previous studies have provided hints that this learning process might start very early in life. First, for some aspects of language, infants learn even before birth (see Cutler, 2012, pp. 259-301, for a review); e.g., newborn infants with an average age of two days prefer to listen to a passage that they have heard in the womb over a new passage (Decasper & Spence, 1986), and neonates younger than three days old already recognize the voice of their mother (DeCasper & Fifer, 1980). Second, electroencephalography/event-related potentials (EEG/ERP) studies have shown that infants are already sensitive to phoneme categories during the first week of life (Dehaene-Lambertz & Peña, 2001), and that infants' auditory memory is functional at birth (Benavides-Varela, Hochmann, Macagno, Nespor, & Mehler, 2012); thus, they possess at least some of

the prerequisite skills for phonological learning. Third, it has been shown that Broca's area, which is associated with speech production, is already active in three months old infants when they hear speech, meaning that even when infants cannot speak yet, the brain areas specialized for speaking are already developing under the influence of the native language (Dehaene-Lambertz et al., 2006). All those studies show that infants are already influenced by their language environment. It can be envisioned that infants younger than six months have already accumulated some knowledge of their native phonology.

The studies reviewed above provide an indication of the linguistic development that can be expected for international adoptees as well. International adoptees who are between the age of six and 12 months might already have a substantial knowledge about the sound system of their birth language, even if they do not show any overt signs of this (i.e., if they do not speak any words yet). Children who are adopted at a later age will, of course, generally have a more advanced knowledge of the birth language. Finally, even though there is little evidence that children under six months of age have already tuned in to the sounds of the native language, the exposure that they have received might have started to shape their perceptual system.

1.3 The effect of early language exposure

In the most common scenario, people will keep using their birth language throughout their life. In more unusual cases, children start out being exposed to a certain language (either as their native language or as a second language) but at some point during childhood, something changes in their lives such that they do not receive as much input in that language anymore, e.g., they migrate with their parents, or a grandparent who spoke a heritage language with them passes away. In such cases, although the input is strongly reduced, some contact with

the language is usually still present. In the case of international adoptees, often, all exposure to the birth language comes to an abrupt end at the time of adoption.

Previous studies have shown that, as long as there is at least some continued exposure, the phonological knowledge that children have obtained persists into adulthood. English learners of Hindi who had been exposed to Hindi during infancy but heard little Hindi after infancy distinguished a Hindi consonant contrast better than control learners of Hindi (Tees & Werker, 1984). Similarly, English learners of Korean who had used Korean as their dominant language in early childhood, and less regularly after childhood, identified Korean consonants better than a control group of learners of Korean who had not been previously exposed to Korean (J. S. Oh, Jun, Knightly, & Au, 2003). Moreover, those learners were also found to *produce* the childhood-language phonemes more accurately than the control group (Au, Knightly, Jun, & Oh, 2002; Knightly, Jun, Oh, & Au, 2003; J. S. Oh et al., 2003). Taken together, these findings show that with continuous usage, if only minimal, phonological knowledge gained in infancy persists into adulthood, and this persistent knowledge gives learners an advantage when relearning to perceive and produce the sounds of the language later in life.

There is, however, no certainty about whether the phonological knowledge gained in infancy can be maintained without any continued usage. Previous studies have suggested that for international adoptees who are entirely cut off from the birth language, even several years of listening to and speaking a native language in childhood might not leave any memories about the language. Thus, adult Korean adoptees who were adopted by French-speaking families at between three to nine years of age did not outperform native French control participants in discriminating Korean phonemes (Ventureyra et al., 2004). The same population (but now adopted at between three to eight years old) again did not perform

differently from native French control participants in various behavioral metalinguistic tasks and a functional magnetic resonance imaging (fMRI) study (Pallier et al., 2003).

Recent studies, on the other hand, suggest that there might be linguistic memory retained that is just not evident right away. Linguistic memory gained in early life might persist in an inaccessible form, and might become accessible again by re-exposure to the language. This has been shown to be the case for children who had been adopted 10 years before testing on average, and had been fully disconnected from the birth language. With a well-controlled re-exposure procedure, eight children who were adopted from India by English-speaking families were trained in and tested on discrimination of a phoneme contrast from their birth language (Singh, Liederman, Mierzejewski, & Barnes, 2011). The results showed that before training, there was no difference between the adopted children and a group of native English control children, but crucially, after training, the adopted children performed better than the native English control children. Thus, the study provides evidence for retained birth-language memory during childhood several years after adoption. It still remains unclear however, whether such birth language memories also persist into adulthood.

Using a relearning approach, three studies carefully suggest that such memories might be retained beyond childhood. First, assessing non-adoptees, Bowers, Mattys, and Gage (2009) compared seven adult native listeners of English who were exposed to either Hindi or Zulu as a second language for four to 10 years in childhood with four control participants who were not previously exposed to either of those languages. None of the participants had been re-exposed to the childhood language, and none had studied Hindi or Zulu before the time of participation. Participants were trained on the perceptual discrimination of two Hindi consonant contrasts and one Zulu consonant contrast. As a result of this training, three out of seven participants who were exposed to Hindi or Zulu during childhood improved in discriminating the contrast(s) of the language they had been exposed to in childhood, but not

in discriminating the contrast(s) of the other language; the rest of the participants did not improve at all during training. Although the analysis relies on individual data from a small number of participants, so that generalization of the finding is difficult, this study does provide a careful hint that linguistic memories from childhood might survive into adulthood.

Experimentally controlled relearning studies such as the study described above are not available for adoptees. The other two studies did investigate international adoptees, but training was not part of the study; rather, the participants were studying their birth language in a university level language course. In the second study, Swedish adult learners of Korean who were adopted by Swedish-speaking families at an age of between three months and 10 years were compared with a control group of Swedish learners of Korean who had no early exposure to Korean (Hyltenstam, Bylund, Abrahamsson, & Park, 2009). The adoptees did not outperform the control group on a Korean grammaticality judgment task and a Korean phoneme discrimination task. In the phoneme discrimination task, however, a few individual adoptees received exceptional scores, higher than the highest score of the control group, which the authors interpret as evidence for memories of phonological knowledge that the adoptees obtained in early life. Note however that the averages of the two groups did not differ, and that other adoptees scored *lower* than the lowest score of the control group, which seems to contradict the authors' conclusion about the presence of a general relearning benefit for the adoptees. Note also that the results are difficult to interpret, as neither the quantity nor the quality of exposure to Korean were tightly controlled; for example, prior to the study, the adoptees had studied Korean in Sweden for a period of time varying from 0.5 to six years, whereas the control participants had studied Korean for one to 13 years (Hyltenstam et al., 2009).

In the third study, again, adult learners of Korean who were adopted from Korea were compared with a control group of learners of Korean who had no early exposure in Korean (J.

S. Oh, Au, & Jun, 2010). In this study, adoptees were adopted by English speaking families, at an age of between three months and three years, and control participants were native speakers of English. Overall, the Korean adoptees did not outperform the control group in identification of Korean phonemes. The adoptees, however, seemed to outperform the controls on some consonant types. As in the study of Hyltenstam et al. (2009), however, the participants were enrolled in a Korean language course which was not part of the study, such that the amount of input and practice was not under experimental control and may have varied between the adoptees and controls (e.g. due to differences in motivation).

Thus, these three studies provide some hints that memories of the birth language might persist into adulthood, even if there is no continued exposure to the language, and that such memories might become accessible again through re-exposure. The three studies above assessed only the *perception* of the phonology of the birth language or other childhood language. Other studies showed that for non-adoptees who had some continued exposure to their childhood language, the language memories also facilitated *production* of sounds of that language (Au et al., 2002; Knightly et al., 2003; J. S. Oh et al., 2003); note that no previous studies have investigated this for adoptees. The present study aims to investigate whether adult adoptees show evidence of a relearning benefit both in perception and in production of the sounds of their birth language. Importantly, this is the first study to investigate memory of birth language phonology for adult adoptees with an experimentally controlled retraining study.

1.4 The present study

The major objective of the present study is to investigate whether Korean adoptees in the Netherlands who were adopted by Dutch-speaking families during childhood retain any phonological knowledge of Korean by the time they reach adulthood. To that end, a large

number of Korean adoptees and Dutch control participants, who did not study Korean prior to the current study, were trained and tested with Korean consonant contrasts. We assess whether the Korean adoptees outperform the Dutch control participants in learning to perceive and produce the consonants. The results of the Korean adoptees and the Dutch controls are also compared to those of another control group of native speakers of Korean.

Participants in the Dutch control group were matched to the adoptees on a number of variables (see Chapter 2). Part of the Dutch control group consisted of Dutch non-adopted siblings or partners of Korean adoptees; for reasons of feasibility, the other part consisted of Dutch listeners who did not have any particular relationship with Korean adoptees. (The results of the two subgroups are compared in each of the experimental chapters.)

1.4.1 Reasons for studying Korean

There are several reasons why the present study investigates Korean adoptees rather than any other population of international adoptees. First, Korean adoptees were chosen in order to maximize the time that has elapsed since adoption. In the Netherlands, adoption from Korea began in the late 1960s; it was the first time international adoption from outside Europe took place on a large scale (Juffer & Van IJzendoorn, 2007). The adoption from Korea reached its peak in the 1970s and 1980s (Juffer & Van IJzendoorn, 2007), and thus most of the Korean adoptees in the Netherlands are presently adults.

A second reason for investigating Korean adoptees for this study is that Korean is not commonly heard in the Netherlands. Thus, the chance that participants were exposed to Korean in everyday life was very small, and thus the amount of (re)exposure to Korean was presumably controlled.

A final reason to investigate Korean adoptees is that the Korean language contains phonemes that are very difficult to learn for Dutch listeners. Korean and Dutch stop

consonants are very different. Korean has a three-way contrast among the stop consonants that are all voiceless word-initially (Broersma, 2010b; Cho, Jun, & Ladefoged, 2002), whereas Dutch has a two-way stop contrast, i.e., voiced versus voiceless (Gussenhoven, 1999). Therefore, native listeners of Dutch have difficulty hearing the difference among the Korean three-way voiceless stop contrast (Broersma, 2010a), and there should be enough room for improvement for the participants throughout the training.

1.4.2 Research questions

This dissertation investigates whether Korean adoptees in the Netherlands retain any phonological knowledge of Korean by the time they reach adulthood, as evidenced by a relearning benefit in perception and/or production of Korean stops, compared to the Dutch control participants.

First, it is investigated whether the Korean adoptees outperformed the Dutch control participants when (re)learning to identify Korean consonant contrasts. The participants were trained to identify a Korean lenis, fortis, aspirated three-way stop contrast at the alveolar place of articulation ([t, t*, t^h]), during 13 training sessions over a period of two weeks. In a pre-, intermediate, and post-test, participants were tested on the identification of the trained alveolar contrast, and of similar three-way contrasts at untrained bilabial ([p, p*, p^h]) and velar places of articulation ([k, k*, k^h]) to assess generalization of learning. If the adoptees' early acquired knowledge of Korean remains and gives them a relearning advantage in adulthood, the adoptees might outperform the Dutch control participants in the identification of the Korean consonants (Chapter 3).

Second, it is explored whether the adoptees produced the Korean contrasts in a more native-like way than the Dutch control participants. The adoptees and control participants performed two production tests, a pre-test after the first perceptual training block and a post-

test after the 13th perceptual training block, during which they produced the lenis, fortis, and aspirated stops at all three places of articulation (alveolar, bilabial, and velar). Based on previous studies that have showed an effect of perceptual training on the production of difficult non-native contrasts (Bradlow, Akahane-Yamada, Pisoni, & Tohkura, 1999; Bradlow, Pisoni, Akahane-Yamada, & Tohkura, 1997), it is expected that improvement will be observed in the pronunciation of the Korean contrasts. The critical question is whether the improvement is greater for the adoptees than for the Dutch control participants (Chapter 4).

Next, it is investigated whether the adoptees' early exposure to the birth language is beneficial for learning a new phoneme contrast of a different language, which contains phonological features similar to the critical birth language contrast. For this purpose, the adoptees and Dutch controls were trained and tested with a Japanese long versus short consonant contrast which is to some extent similar to the Korean fortis versus lenis consonant contrast. If adoptees can generalize their phonological knowledge of the birth language to a novel contrast, the adoptees might perform better than the Dutch control participants in learning to identify the Japanese contrast (Chapter 5).

Finally, to complement the identification tasks of Chapters 3 and 5, the adoptees and the Dutch control participants were tested on the *discrimination* of the same Korean and Japanese contrasts, in a pre-test, intermediate test, and post-test. Phoneme identification and discrimination tasks have been proposed to require different perceptual processes (Broersma, Dediu, & Choi, 2013; Gerrits & Schouten, 2004; Sadakata & McQueen, 2013). If the early experience with the birth language gives the adoptees a greater perceptual sensitivity to the target contrasts, the adoptees might outperform the Dutch control participants in the discrimination tasks too (Chapter 6).

For all experiments, it is explored whether age of adoption affects the adoptees' performance. If the length of experience with the birth language in childhood influences

performance in adulthood, there should be an effect of age of adoption on the adoptees' performance.

For all experiments, it is also assessed whether there is a difference between the performance of those control participants who were siblings or partners of a Korean adoptee and those controls who did not have such a relationship with a Korean adoptee. The siblings and partners were presumed optimal control participants for this study. If there is no difference between the 'related' and 'unrelated' Dutch controls, this will suggest that the control group can be considered as appropriate as a control group that entirely comprises 'related' Dutch controls.

Finally, in all of the experiments, native Korean control participants took part in a single test session (without training). The results of the Korean control participants were compared to those of the adoptees and the Dutch controls, in order to assess to what extent the adoptees and the Dutch controls reached a level of Korean native-like performance before or after the extensive training on the target contrasts.

1.4.3 Structure of this dissertation

Chapter 2 describes the general method, including detailed descriptions of the participants, and of the general procedure for training and testing, as well as the method and results for the training. Chapters 3 to 6 describe the experiments conducted. Chapter 3 investigates the identification of Korean consonant contrasts, Chapter 4 the production of those consonants. Chapter 5 investigates the identification of Japanese consonant contrasts. Chapter 6 investigates the discrimination of the Korean and Japanese contrasts. Finally, the findings are summarized and discussed in Chapter 7.

2 General Method

2.1 Participants

Twenty-nine Korean adoptees (21 female, eight male, M_{age} = 31.66 years, range: 23-41 years) in the Netherlands, 29 native Dutch control participants (16 female, 13 male, M_{age} = 32.03 years, range: 19-47 years), and 25 native Korean control participants (14 female, 11 male, M_{age} = 29.56 years, range: 27-37 years) participated in this study. All participants had at least completed high school. None reported any hearing loss, uncorrected visual loss, or reading disability. All participants received a monetary reward for their participation.

The age of the adoptees when adopted by Dutch-speaking families in the Netherlands ranged from three to 70 months (i.e., five years and 10 months, henceforth 5:10 years) (M = 21.38, SD = 20.10) (see Figure 2.1). They had been in the Netherlands for 23:8 to 40:0 years at the time of testing. None of them had learned Korean after adoption. Thirteen of the adoptees had never been back to Korea after adoption; the other sixteen adoptees had been back to Korea after adoption for short visits (range: nine to 28 days per trip), once for 12 adoptees, two times for three, and three times for one adoptee. Adoptees were recruited with the help of the Dutch Association for Korean Adoptees Arierang and through informal networks.

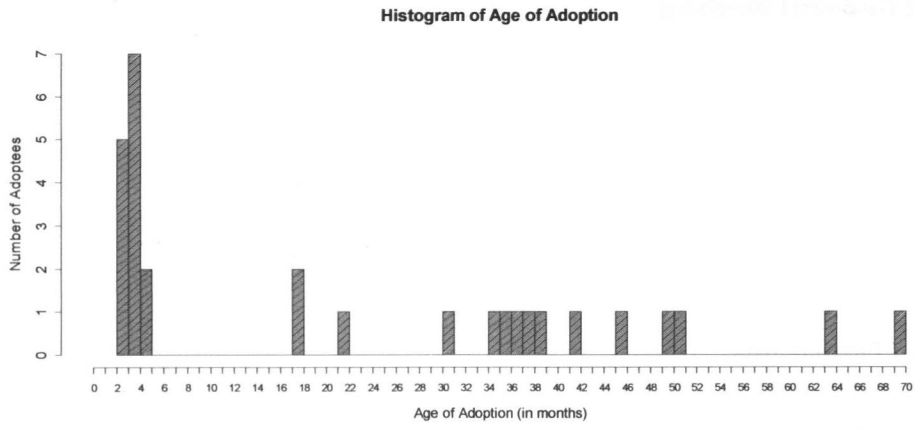

Figure 2.1. Frequency distribution of the age of adoption of the Korean adoptees

The Dutch control participants had not learnt Korean. They were recruited in a similar way as the adoptees, and carefully selected to match the adoptees in terms of six control variables which might affect learning in general or learning Korean contrasts in particular: (a) Sex, (b) Age at test, (c) Visit: whether or not participants had visited Korea (after adoption for the adoptees), (d) Visit Ratio: the ratio of how many days participants stayed in Korea to how many days ago they visited Korea, (e) Schooling: the highest level of high school completed among the four levels in the Dutch high school system (i.e., from lowest to highest, VBO, MAVO, HAVO, and VWO), (f) Number of Languages participants knew (if only a little). The adoptees and the Dutch controls were not significantly different on any of the control variables (see Table 2.1 for descriptive statistics): Sex, $\chi^2(1) = 1.866$, $p < .10$; Age, $t(56) = -.235$, $p < .10$; Visit, $\chi^2(1) = .069$, $p < .10$; Visit Ratio, $t(56) = .429$, $p < .10$; Schooling, $\chi^2(3) = 2.210$, $p < .10$; Number of Languages, $t(56) = .879$, $p < .10$.

Table 2.1. Summary of descriptive statistics of Korean adoptees and Dutch controls for the six control variables

Variable	Adoptees			Dutch controls		
	n	%	*M* (*SD*)	n	%	*M* (*SD*)
Sex						
Female	21	72.4		16	55.2	
Male	8	27 6		13	44 8	
Age	29		31.66(5 30)	29		32 03(6 90)
Visit						
Yes	16	55 2		15	51 7	
No	13	44.8		14	48 3	
Visit Ratio	29		0.01(0.02)	29		0 01(0 02)
Schooling						
VBO	2	6.9		2	6.9	
MAVO	8	27 6		7	24 1	
HAVO	9	31 0		5	17 2	
VWO	10	34 5		15	51.7	
Number of Languages	29		2.83(1.07)	29		2 59(1 02)

Half of the Dutch control participants (15/29) were related to Korean adoptees (nine controls were siblings and six were partners of Korean adoptees), to match them with the adoptees in terms of socio-economic background and, possibly, motivation. In order to assess the motivation for participation, all participants were asked to answer an open-ended question about their reasons for participation. As shown in Table 2.2, importantly, the adoptees and Dutch controls answered the question in a highly similar way: The majority of responses from both groups were "Mere interest" and "To help research". As expected, one marked difference in the answers from the two groups was that, naturally, only the Dutch control participants indicated that they participated for their partners or siblings.

Table 2.2. Reasons for participation

Reason	Adoptees	Dutch controls
	Number (%)	Number (%)
Mere interest	13 (34)	6 (21)
To help research	11 (29)	11 (39)
Interest in Korea (culture, language, or people)	7 (18)	4 (14)
Interest in adoption	1 (3)	2 (7)
Monetary reward	1 (3)	2 (7)
Other	5 (13)	3 (11)
Subtotal	38 (100)	28 (100)
For partner or sibling	--	6

Note. There were 38 responses from the adoptees and 34 from the Dutch controls. Responses in the category "For partner or sibling" were excluded from calculation of the percentages, to make the percentages for adoptees and Dutch controls more easily comparable. Each response in the category "Other" occurred only once.

In order to assess the adoptees' and the Dutch controls' conscious knowledge of Korean, a word recognition test was carried out after completion of the main experiments. The test consisted of 10 Korean words, that have been shown to be comprehended by 50% of Korean children before the age of 12 months (Pae & Kwak, 2011; using the MacArthur-Bates Communicative Development Inventory, henceforth CDI). A female native speaker of Korean recorded the words in a clear citation style in a soundproof booth. Participants were instructed to listen to the Korean words and choose the Dutch translation from three alternatives. They were asked to guess if they did not know. On each trial, the participants listened to three different recordings of one word. After that, they saw three Dutch words in a bulleted list on a computer screen and indicated which word they thought to be the correct translation (see Appendix A for all materials). The response options consisted of the 10 correct translations and 20 alternative words. For the selection of the alternative words, English CDI norms were used, because no Dutch CDI norms are available; the 20 alternative

words were Dutch translations of English words that have been shown to be comprehended by 50% of American English children before the age of 12 months (Fenson et al., 1994). The test was self-paced. The percentage correct was above chance, $t(57) = 7.456$, $p < .05$; this might be due to prosody or the onomatopoeic nature of some of the Korean words. Importantly, the number of correct responses did not differ between the adoptees ($M_{\%\ correct} = 46.62$, $SD = 17.20$) and the Dutch controls ($M_{\%\ correct} = 48.28$, $SD = 10.71$), $t(56) = -.550$, $p < .10$.

The native Korean control participants were recruited with flyers posted at Hanyang University in Seoul, South Korea.

2.2 General Procedure

For the adoptees and Dutch controls, there were 13 perceptual training blocks, three test sessions on perception (pre-test, intermediate test, post-test), and two test sessions on production (pre-test, post-test). During the training, participants were trained to identify the Korean three-way stop contrast and the Japanese three-way length combination. In the test sessions on perception, the participants were tested on identification and discrimination of the Korean stop contrasts and the Japanese length combination. Finally, in the test session on production, they were asked to produce the Korean stop consonants.

Training and testing took place in a quiet room, on a location chosen by the participants (in most cases in their own home or workplace), to keep participation feasible for the participants. Training and testing took place over a period of 11 days (with six exceptions due to unforeseen scheduling reasons: 10 days for four participants, 12 days for two participants). During that period, the experimenter (the author) visited the participants four times with intervals of two or three days (also with 12 exceptions due to scheduling reasons,

where visits had one-day or four-days intervals; 5% of the visits). In addition, the participants carried out six homework training blocks individually (see Table 2.3).

On the first visit, the initial performance of the participants' perception and production was assessed by pre-tests. (Note that the production pre-test was carried out *after* the first perceptual training block, in order to familiarize the participants during the training with the mapping of visual symbols onto each of the three sound categories; during the production tests, the symbols were presented to the participants to inform them which sound category they were supposed to produce.) The learning effect on perception was assessed by an intermediate test after the fourth training block and by a post-test after the last (13^{th}) training block. The learning effect on production was assessed by a post-test after the last (13^{th}) training block. For the training, on the first visit, participants completed one training block; on each of the other visits, they completed two training blocks. Between every two visits they completed two training blocks as homework, with equipment (a laptop and headphones) provided to them by the experimenter.

During the visits, participants received further exposure to Korean in the shape of sentences, short stories, and possible but non-existing Korean words, spoken by several male and female native speakers of Korean, in the context of various experimental tasks — including phoneme monitoring, voice recognition, emotion recognition, and speech segmentation experiments — to be reported elsewhere. This additional exposure was the same for all participants.

The native Korean control participants did not receive any training or further exposure to Korean, and only performed the perception and production *pre-tests*, because they were expected to perform almost perfectly for the Korean stop contrasts without any training, and because their learning of the Japanese three-way length combination was not of primary interest in this study.

Table 2.3. Timing of testing and training over 11 days

Day	Visit / Homework	Activity (listed in chronological order)
1	1st visit	perception pre-test, training1, production pre-test
2, 3	Homework	training 2, training 3
4	2nd visit	training 4, perception intermediate test, training 5
5, 6, 7	Homework	training 6, training 7
8	3rd visit	training 8, training 9
9, 10	Homework	training 10, training 11
11	4th visit	training 12, training 13, perception post-test, production post-test

Note. Schedules sometimes diverged with ± 1 day.

In all sessions, participants were seated in front of a laptop. They heard materials through high quality headphones. The participants were prompted to adjust the volume to a comfortable level. They saw instructions and feedback on the screen of the laptop. For training and perception tests, responses were given by pressing keys on the laptop keyboard. For production tests, recordings were made at a sampling rate of 44 kHz with a Zoom Handy Recorder H2 and a Rode SVM N3594 microphone. Each training block and each production test lasted approximately 15 minutes, and each perception test 50 minutes. Presentation software (from the 14 series, Neurobehavioral Systems Inc.) was used for constructing and running the experiment.

2.3 Training Method and Results

An identification task was used for training. This task is efficient to force participants to form novel phonemic categories and to facilitate generalization to novel stimuli which have not been presented during training (Logan & Pruitt, 1995). In order to provide participants with a large set of acoustic cues for the target contrasts, which has been shown to help learners to

acquire robust target phonemic categories (Lively, Logan, & Pisoni, 1993), several speakers recorded the training stimuli. Each of the 13 training blocks began with a sub-block for the Korean three-way stop contrast followed by a sub-block for the Japanese three-way length combination.

2.3.1 Korean stops

The crucial contrast was a Korean three-way stop contrast among fortis, lenis, and aspirated stops. Participants were trained to identify the three-way contrast at the alveolar place of articulation [t*, t, t^h].

2.3.1.1 Materials

Twenty-five minimal triplets of consonant-vowel-consonant-vowel (CVCV) Korean pseudowords were created. Within each triplet, items varied only in word-initial fortis, lenis, and aspirated alveolar stops [t*, t, t^h]. The initial syllables consisted of the crucial stops followed by the vowels [a], [e], [i], [o], or [u]. There were five final syllables, containing five other consonants which were not stops and the same five vowels: [ra, he, mi, tjo, su]. Initial and final syllables were exhaustively combined, yielding the 25 minimal triplets (Appendix B).

Five male and five female native speakers of standard South Korean (age range: 22-33 years) recorded the triplets. Each of them recorded multiple tokens of all 75 items (i.e., 25 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 (Boersma, 2001). One token of each item was selected for each of the 10 speakers for the training.

For the instructions preceding all training blocks, one additional token from one of the male speakers was selected, for two of the minimal triplets ([t*ora]-[tora]-[t^hora] and [t*uhe]-[tuhe]-[t^huhe]).

2.3.1.2 Procedure

The adoptees and Dutch controls completed 13 training blocks, training the perception of the Korean alveolar stops. The first 10 training blocks contained stimuli from one speaker per block (with 75 tokens per speaker); speakers were presented in a fixed order to all participants. For the last three blocks, the speakers were mixed: the 11^{th} block contained stimuli from the five female speakers (with 15 tokens per speaker), the 12^{th} block from the five male speakers (15 tokens per speaker), and the 13^{th} block contained stimuli from all 10 speakers (with seven to eight tokens per speaker).

A three-alternative forced-choice identification task was used. Each training block started with instructions, followed by six practice trials, a break during which participants could ask questions, and the main training phase.

Participants read instructions that they would hear a series of stimuli. They were instructed to listen carefully to the first sound of each stimulus and to categorize it into one of three categories. Next they were informed which response keys corresponded to each of the three sound categories: Participants heard two minimal triplets (see Materials section, above) twice with an interstimulus interval (ISI) of 1800 ms. Simultaneously, they saw three symbols on the computer screen while the intended symbol was highlighted. The symbols represented the response keys: "!" for fortis, "@" for lenis, and "#" for aspirated stops. Note that the response keys are adjacent on the computer keyboard.

During the main training phase, each trial started with a fixation mark on the screen for 400 ms, followed by a 400 ms delay, after which one auditory stimulus was played.

Participants indicated which initial stop they thought they had heard by pressing one of the three response keys. After a correct response, a high-pitch beep (duration: 75 ms, pitch: 290 Hz) was immediately played, and the Dutch word for "good" was displayed in green. After an incorrect response, a low-pitch beep (duration: 290 ms, pitch: 157 Hz) was immediately played, and the Dutch translation of "the correct answer is:" was displayed in red, followed by the correct symbol. Visual feedback was displayed for 1300 ms. There was no time-out for responses. For each participant, in each training block, all 75 stimuli were presented, in a random order.

The main training was preceded by six practice trials, identical to the training trials, containing tokens from the same speaker(s) used in that block.

2.3.1.3 Results

To ascertain that no unexpected results were found in the training, the results of the 13 training blocks were analyzed. Note that a linear increase of the percentage correct was not expected. First, the difficulty of the task varied because different speakers were used in the first 10 blocks; previous work has shown that identification accuracy of non-native phonemes varied widely depending on the speakers (Lively et al., 1993; Logan, Lively, & Pisoni, 1991). Second, the difficulty was increased by including several speakers in the last three blocks. Analyses of Variance (ANOVAs) were carried out across participants (*F1*) and across items (*F2*) with the variables Training block (block 1 to 13), Target type (fortis, lenis, aspirated), and Group (adoptee, Dutch control). There was no effect of Group and there were no interactions with Group. There was a main effect of Training block, $F1(12, 672) = 20.895$, $p < .05$, $\eta_p^2 = .272$; $F2(12, 864) = 28.935$, $p < .05$, $\eta_p^2 = .287$, and an interaction between Training block and Target type, $F1(24, 1344) = 8.716$, $p < .05$, $\eta_p^2 = .135$; $F2(24, 864) = 9.033$, $p < .05$, $\eta_p^2 = .201$; as expected, percentages correct fluctuated, probably as a result of

both the speaker(s) and the number of speakers in each block. For figures of the percentage correct in the training, see Appendix C. These analyses confirmed that the training was performed as anticipated and did not show any unexpected outcomes.

2.3.2 Japanese fricatives

A Japanese three-way length combination was used, consisting of (1) a long fricative preceded by a short vowel (henceforth Geminate), (2) a short fricative preceded by a short vowel (henceforth Singleton), and (3) a short fricative preceded by a long vowel (henceforth Long Vowel). Participants were trained to identify the three-way length combination.

2.3.2.1 Materials

Twenty-five minimal triplets of vowel-consonant-vowel (VCV) items were created. The triplets contrasted the Geminate, Singleton, and Long Vowel targets using voiceless labiodental fricatives, e.g., [af:e]-[afe]-[a:fe]. The vowels [a], [e], [i], [o], and [u] were exhaustively combined in the first and the second vowel position, yielding the 25 minimal triplets.

Five male and five female native speakers of Japanese (either Standard Japanese or West dialect; age range: 28-47 years) recorded the triplets. The further construction procedure was identical to that of the training materials for the Korean stop contrast.

Again, for the instructions preceding all training blocks, one additional token from one of the male speakers was selected for two minimal triplets ([of:a]-[ofa]-[o:fa] and [uf:e]-[ufe]-[u:fe]).

2.3.2.2 Procedure

The adoptees and Dutch controls completed 13 training blocks, training the perception of the Japanese three-way length combination. The procedure was identical to that of the training procedure for the Korean stop contrast, except for different symbols representing the response keys: "*" for the Geminate, "^" for the Singleton, and "&" for the Long Vowel targets. Note that the response keys are adjacent on the computer keyboard.

2.3.2.3 Results

As with the training results of the Korean stop contrast, ANOVAs were carried out across participants (*F1*) and across items (*F2*) with the variables Training block (block 1 to 13), Target type (Geminate, Singleton, Long Vowel), and Group (adoptee, Dutch control). Note that, again, there was no reason to expect a linear increase of the percentage correct across the blocks, because of the different (number of) speakers used in each block. There was no effect of Group and no interaction between Training block and Group. There was a three-way interaction among all variables, $F1(24, 1344) = 1.716$, $p < .05$, $\eta_p^2 = .03$; $F2(24, 864) = 3.018$, $p < .05$, $\eta_p^2 = .077$. Similar ANOVAs were undertaken, separately for the Geminate, Singleton, and Long Vowel targets, and none of the analyses showed an effect of Group or an interaction between Training block and Group. Again, as for the Korean stop contrast, percentage correct fluctuated from block to block, probably due to the same reason as for the Korean contrast. For figures of the percentage correct in the training, see Appendix D. These analyses confirmed that the training on the Japanese length combination was also performed as expected.

3 Perception of Korean stops (Identification task)

3.1 Introduction

Previous studies suggest that adult adoptees retain no direct access to knowledge of their birth language (Pallier et al., 2003; Ventureyra et al., 2004), but that phonological knowledge might become accessible again with extensive training (Hyltenstam et al., 2009; for a study on early language experience in non-adoptees, see Bowers et al., 2009). The present study examines whether the Korean adoptees in the Netherlands, after being disconnected from Korean for several decades, preserve any accessible knowledge of Korean into adulthood.

As described in the General Method chapter, adoptees and Dutch control participants were trained to identify the Korean three-way stop contrast at the alveolar place of articulation ([t, t*, t^h]); they received 13 training sessions over a period of two weeks. As part of the multi-session training and testing sequence, the adoptees and the Dutch controls performed three perception tests, a pre-test before the training, an intermediate test after the fourth training block, and a post-test after the last (13^{th}) training block. In the present study, the question at issue is whether the adoptees outperformed the Dutch control participants on the identification of the trained alveolar contrast, and on similar three-way contrasts at two untrained places of articulation, namely bilabial ([p, p*, p^h]) and velar ([k, k*, k^h]), during the three tests. If the adoptees have preserved any knowledge of Korean which they gained in early childhood, they may outperform the Dutch control participants.

In order to assess how the participants' perception of the phoneme categories developed as a result of the training, a phoneme identification task was used. The phoneme identification task is the most direct measure of how well participants can recognize specific speech sounds. The phoneme identification task was similar to that used during the training, except that feedback was given during the training but not during the test.

3.2 Method

3.2.1 Participants

The same participants as described in the General Method (Chapter 2) — 29 Korean adoptees, 29 native Dutch control participants, and 25 native Korean control participants — participated.

3.2.2 Materials

The crucial contrast was the Korean three-way fortis, lenis, and aspirated stop contrast. At test, perception was tested at three places of articulation: alveolar [t*, t, t^h], bilabial [p*, p, p^h], and velar [k*, k, k^h]. During the training, on the other hand, only the alveolar place of articulation was presented.

For each of the three places of articulation, 25 minimal triplets were created. The triplets for the alveolar contrast were identical to those used for the training (see Chapter 2.3.1.1). The triplets for the bilabial and velar contrasts were constructed in a similar way as those for the alveolar contrast.

A female native speaker of standard South Korean (22 years old) recorded the 225 items (i.e., 75 triplets = 25 triplets * 3 places of articulation). The items were recorded as for the training stimuli. One token of each item was selected for the test.

For the instructions used in all test sessions, some example stimuli were recorded by a male native speaker of standard South Korean (21 years old, one of the speakers who recorded the training stimuli), for each place of articulation ([t*ora]-[tora]-[t^hora], [t*uhe]-[tuhe]-[t^huhe], [p*ara]-[para]-[p^hara], [p*ehe]-[pehe]-[p^hehe], [k*ihe]-[kihe]-[k^hihe] and [k*ura]-[kura]-[k^hura]).

3.2.3 Procedure

As described in the General Method, all 29 adoptees and 29 Dutch control participants participated in a pre-test (before the first training block), an intermediate test (after the 4th training block), and a post-test (after the 13th training block), while the 25 Korean control participants took part in one test (with no training).

Each pre-, intermediate, and post-test consisted of three blocks. These three blocks tested the Korean three-way contrasts of alveolar, bilabial and velar stops, respectively, always in that order. A three-alternative forced-choice identification procedure was used in the tests. Each block began with instructions, six practice trials, an opportunity to ask questions, and the main test phase. The further procedure was the same as that for the training (Chapter 2.3.1.2), except that there was no feedback about the correctness of the responses during the main test phase.

3.3 Results

First, and importantly, we ask whether the adoptees outperformed the Dutch control participants in identifying the Korean three-way stop contrasts. Second, the participants' performance for the trained versus the untrained places of articulation is compared. Third, for the adoptees, the effect of age of adoption on their performance is investigated. Next, the Dutch control participants who were related to Korean adoptees (i.e., siblings or partners of

Korean adoptees) are compared with the control participants who were not related to Korean adoptees. Finally, the results of the native Korean control participants are compared to the post-test results of the adoptees and the Dutch control participants.

For all analyses, proportions of correct responses were used as dependent variable. (Note that the figures and tables show percentages rather than proportions for ease of interpretation.) One hundred and twenty-three responses with reaction times longer than 10,000 ms (0.3% of all responses) were considered as outliers and excluded from analysis.

3.3.1 Adoptees versus Dutch control participants

First, we explore whether the adoptees performed better than the Dutch control participants in identifying the Korean three-way stop contrasts at the pre-, intermediate, and post-tests.

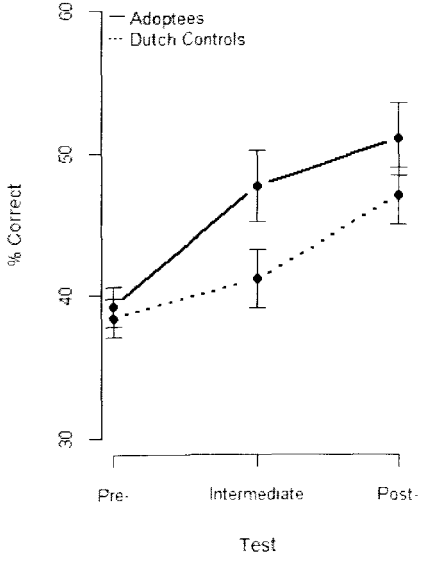

Figure 3.1. Percentage correct for Korean adoptees and Dutch controls, at pre-, intermediate, and post-tests (collapsed over place of articulation). Error bars represent standard errors.

As Figure 3.1 shows, both groups performed equivalently at the pre-test but, importantly, the adoptees outperformed the controls at the intermediate test, and the difference between the groups diminished again at the post-test. ANOVAs were carried out across participants (*F1*) and across items (*F2*) with the variables Test (pre-test, intermediate test, post-test), Place of articulation (alveolar, bilabial, velar), Target type (fortis, lenis, aspirated) and Group (adoptee, Dutch control). Indeed, there was a significant interaction between Group and Test, $F1(2, 112) = 3.258$, $p < .05$, $\eta_p^2 = .055$; $F2(2, 432) = 12.704$, $p < .05$, $\eta_p^2 = .056$.

The proportion correct at the pre-test for all participants ($M_{\%\ correct} = 37.77$, $SD = 7.39$) was above chance, $t(57) = 5.940$, $p < .05$. Further analyses confirmed that the two groups performed equivalently at the pre-test, but importantly, the adoptees performed significantly better than the controls at the intermediate test, $F1(1, 56) = 4.061$, $p < .05$, $\eta_p^2 = .068$; $F2(1, 216) = 62.343$, $p < .05$, $\eta_p^2 = .224$. At the post-test, the two groups were no longer significantly different. As can be clearly seen in Figure 3.1, both groups learned between the pre- and intermediate tests, but the adoptees learned more rapidly than the controls: The proportion correct was higher for the intermediate test than for the pre-test for both groups (for the adoptee group: $F1(1, 28) = 16.470$, $p < .05$, $\eta_p^2 = .370$; $F2(1, 216) = 90.568$, $p < .05$, $\eta_p^2 = .295$; for the control group: $F1(1, 28) = 5.245$, $p < .05$, $\eta_p^2 = .158$; $F2(1, 216) = 9.802$, $p < .05$, $\eta_p^2 = .043$), but the adoptees showed a bigger effect size than the controls (see *partial eta squared*, η_p^2, above), resulting in a significant interaction between Test and Group with the pre- and intermediate tests, $F1(1, 56) = 5.712$, $p < .05$, $\eta_p^2 = .093$; $F2(1, 216) = 23.188$, $p < .05$, $\eta_p^2 = .097$. Both groups improved significantly between the intermediate and post-tests, and there was no significant interaction between Test and Group there.

There were significant main effects of Test, $F1(2, 112) = 41.068$, $p < .05$, $\eta_p^2 = .423$; $F2(2, 432) = 139.618$, $p < .05$, $\eta_p^2 = .393$, Place of articulation, $F1(2, 112) = 5.041$, $p < .05$,

η_p^2 = .083; $F2(2, 216) = 4.073$, $p < .05$, η_p^2 = .036, and Target types, $F1(2, 112) = 14.280$, $p < .05$, η_p^2 = .203; $F2(2, 216) = 24.465$, $p < .05$, η_p^2 = .185, as well as significant two-way interactions between those three variables: between Test and Place of articulation (to which we will come back in more detail in Chapter 3.3.2), $F1(4, 224) = 3.086$, $p < .05$, η_p^2 = .052; $F2(4, 432) = 4.302$, $p < .05$, η_p^2 = .038, between Test and Target types,[4] $F1(4, 224) = 10.737$, $p < .05$, η_p^2 = .161; $F2(4, 432) = 31.849$, $p < .05$, η_p^2 = .228, and between Place of articulation and Target types,[5] $F1(4, 224) = 4.017$, $p < .05$, η_p^2 = .067; $F2(4, 216) = 2.471$, $p < .05$, η_p^2 = .044. Note that there was no significant interaction between Group and Place of articulation, indicating that the extent to which the participants generalized what they had learned to a new place of articulation was similar for adoptees and controls.

In sum, the adoptees benefited from their exposure to Korean in early childhood when relearning Korean consonant contrasts later in life. The adoptees and the Dutch controls performed similarly at the pre-test, but, crucially, at the intermediate test, the adoptees performed better than the controls, both at trained and untrained places of articulation. In the post-test, the controls caught up with the adoptees such that both groups performed similarly again. That is, the adoptees were faster than the Dutch control participants in learning to identify the trained contrast, and in generalizing knowledge about the trained contrast to the similar contrasts at new places of articulation.

[4] Analyses following up on the interaction between Test and Target types showed that there was no difference in proportion correct for fortis, lenis, or aspirated targets at the pre-test, but at the intermediate and post-tests, proportion correct was higher for the fortis targets than for lenis or aspirated targets. At the intermediate test, lenis targets also received more correct responses than aspirated targets ($ps < .05$).

[5] Analyses following up on the interaction between Place of articulation and Target types showed that the aspirated targets received fewer correct responses at velar place of articulation than at alveolar or bilabial places of articulation ($ps < .05$)

3.3.2 Trained versus untrained places of articulation

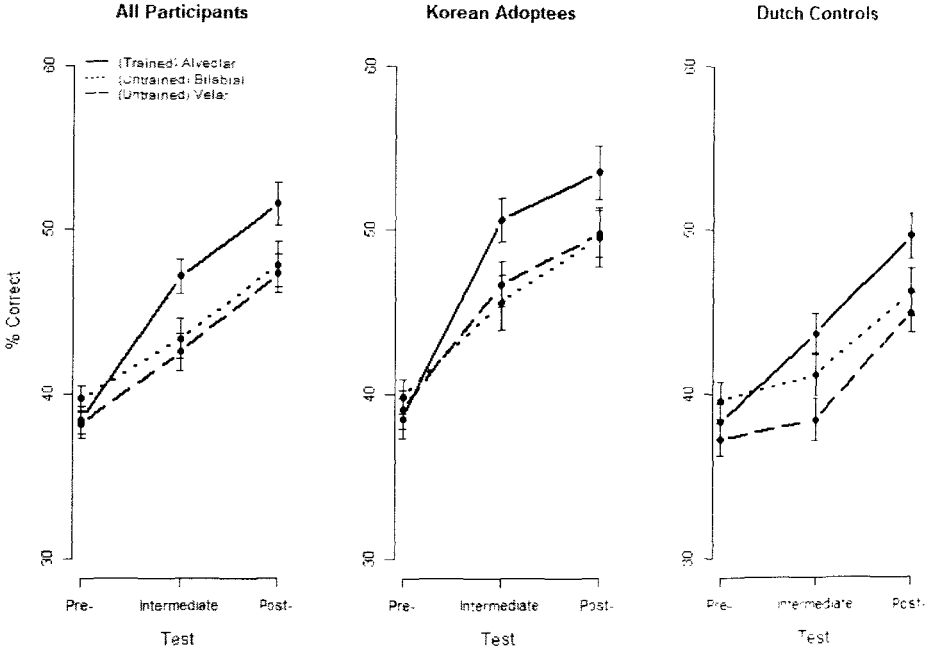

Figure 3.2. Percentage correct, separately for alveolar, bilabial, and velar stops, at pre-, intermediate, and post- tests. Error bars represent standard errors.

It was investigated whether improvement differed between the trained alveolar contrast and the untrained bilabial and velar contrasts. As expected, and as Figure 3.2 shows, performance improved more for the place of articulation that participants were trained on than for the untrained places of articulation, for the adoptees and the Dutch controls alike. This was confirmed by the interaction between Test and Place of articulation. As shown in Figure 3.2, there was no difference in proportion correct for alveolar, bilabial, and velar targets at the pre-test, but at the intermediate and post-tests, proportion correct was higher for the trained alveolar targets than for the untrained bilabial and velar places of articulation (see also Table 3.1 for percentage correct) (for alveolar vs. bilabial at the intermediate test: $F1(1, 56)$ 9.100,

$p < .05$, $\eta_p^2 = .14$; $F2(1, 144) = 6.392$, $p < .05$, $\eta_p^2 = .043$; for alveolar vs. bilabial at the post-test: $F1(1, 56) = 8.525$, $p < .05$, $\eta_p^2 = .132$; $F2(1, 144) = 5.122$, $p < .05$, $\eta_p^2 = .034$; for alveolar vs. velar at the intermediate test: $F1(1, 56) = 9.895$, $p < .05$, $\eta_p^2 = .15$; $F2(1, 144) = 12.296$, $p < .05$, $\eta_p^2 = .079$; for alveolar vs. velar at the post-test: $F1(1, 56) = 11.823$, $p < .05$, $\eta_p^2 = .174$; $F2(1, 144) = 8.409$, $p < .05$, $\eta_p^2 = .055$). Performance, however, improved significantly for the bilabial and velar stops (for bilabials from pre- to intermediate test: $F1(1, 56) = 7.597$, $p < .05$, $\eta_p^2 = .119$; $F2(1, 72) = 9.34$, $p < .05$, $\eta_p^2 = .115$; for bilabials from intermediate to post-test: $F1(1, 56) = 10.694$, $p < .05$, $\eta_p^2 = .160$; $F2(1, 72) = 21.325$, $p < .05$, $\eta_p^2 = .229$; for velars from pre- to intermediate test: $F1(1, 56) = 8.497$, $p < .05$, $\eta_p^2 = .132$; $F2(1, 72) = 16.96$, $p < .05$, $\eta_p^2 = .191$; for velars from intermediate to post-test: $F1(1, 56) = 10.172$, $p < .05$, $\eta_p^2 = .154$; $F2(1, 72) = 25.495$, $p < .05$, $\eta_p^2 = .261$). Note that performance for the alveolar stops also improved significantly (from pre- to intermediate test: $F1(1, 56) = 25.994$, $p < .05$, $\eta_p^2 = .317$; $F2(1, 72) = 65.472$, $p < .05$, $\eta_p^2 = .476$; from intermediate to post-test: $F1(1, 56) = 16.192$, $p < .05$, $\eta_p^2 = .224$; $F2(1, 72) = 25.487$, $p < .05$, $\eta_p^2 = .261$.).

Table 3.1. Percentage correct (and standard error) for alveolar, bilabial, and velar targets at pre-, intermediate, and post-tests, separately for Korean adoptees and Dutch controls

Place of Articulation	Pre-test		Intermediate test		Post-test	
	Adoptees	Dutch Controls	Adoptees	Dutch Controls	Adoptees	Dutch Controls
Alveolar	38.5 (1.2)	38.3 (1.1)	50.6 (1.4)	43.7 (1.2)	53.5 (1.6)	49.7 (1.4)
Bilabial	39.9 (1.1)	39.6 (1.1)	45.6 (1.6)	41.2 (1.2)	49.6 (1.8)	46.2 (1.4)
Velar	39.1 (1.1)	37.2 (1.0)	46.7 (1.3)	38.4 (1.3)	49.8 (1.4)	45.0 (1.2)
Overall	39.2 (1.4)	38.4 (1.4)	47.7 (2.5)	41.1 (2.0)	51.0 (2.5)	47.0 (2.0)

In sum, there was improvement in identifying the Korean consonant contrasts both at the trained alveolar and at the untrained bilabial and velar places of articulation, for the

adoptees and the Dutch controls alike. More improvement was observed for the trained alveolar contrast than the untrained bilabial and velar contrasts, again for the adoptees and the Dutch controls alike.

3.3.3 Age of Adoption

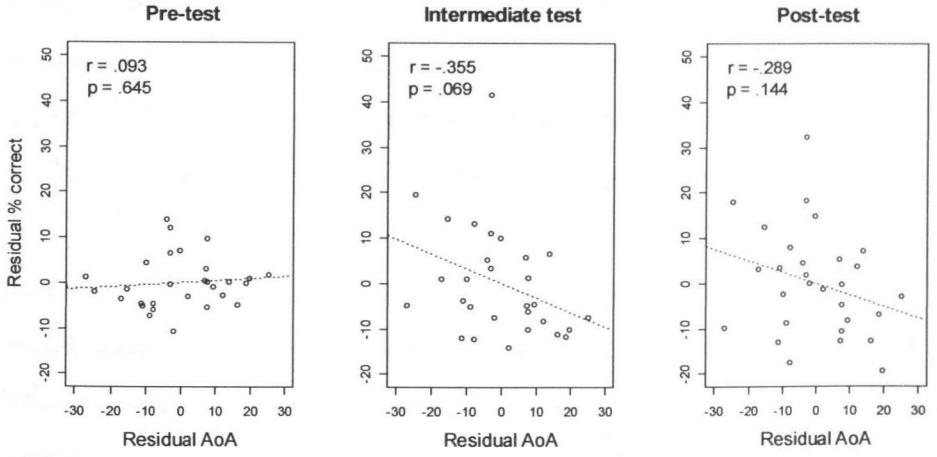

Figure 3.3. Partial regressions between Age of Adoption (AoA) and percentage correct for Korean targets for adoptees on pre-, intermediate, and post-tests (collapsed over place of articulation); the X-axis represents the residuals of the regression of the AoA on Age and Sex; the Y-axis represents the residuals of the regression of the percentage correct on Age and Sex; dotted lines represent regression coefficients.

The effect of Age of Adoption (AoA) on performance for the adoptees was investigated: Partial correlations of AoA and the adoptees' performance at each of the three tests were calculated while controlling for the effect of Age and Sex, which were highly correlated with AoA (for Age: $r_s = .744$, $p < .05$; for Sex: $r_{pb} = -.545$, $p < .05$). (Note that none of the other control variables — Visit, Visit Ratio, Schooling, Number of Languages — was significantly correlated with AoA.) Importantly, after partialling out the effects of Age and Sex, AoA was not significantly correlated with adoptees' performance at the pre, intermediate or post-tests (see Figure 3.3, at pre-test: $r = .093$, $p = .645$; at intermediate test: $r = -.355$, $p = .069$; at post-

test: r = -.289, p = .144). This suggests that the length of exposure to Korean in early childhood did not play a significant role explaining the adoptees' performance in adulthood.

In order to be able to investigate the possible effect of AoA while assessing all independent variables described in section 3.3.1 above, an analysis of covariance (ANCOVA) was carried out. First, using a median split, the adoptees were divided into two groups. The early adopted group contained participants who were adopted before five months of age (N = 14); the later adopted group contained participants adopted after 17 months of age (N = 15). (Note that there were no participants adopted between five months and 17 months of age.) The median split thus results in a cut-off which happens to coincide with a crucial point in infants' phonological development, namely before and after six months of age.

The mean age in the early adopted group (M_{age} = 28.36 years, range: 23 to 39 years) was significantly lower than in the later adopted group (M_{age} = 34.73 years, range: 29 to 41 years), $t(27)$ = -.4.019, $p < .05$; further, the proportion of females was higher in the early adopted group (13/14) than in the later adopted group (8/15), $\chi^2(1)$= 5.663, $p < .05$. The two groups did not differ in any of the other control variables (Visit, Visit Ratio, Schooling, Number of Languages), or in the results of the word recognition test.

An ANCOVA was carried out across participants with the variables Test (pre-test, intermediate test, post-test), Place of articulation (alveolar, bilabial, velar), Target type (fortis, lenis, aspirated) and Binary AoA (early adopted, later adopted). Age and Sex were included as covariates. Importantly, there were no significant effects of Binary AoA, or of any other variables except for a significant interaction between Place of articulation and the covariate Age, $F(2, 50) = 4.207$, $p < .05$, $\eta_p^2 = .144$. Thus, in line with the correlation results, AoA did not affect performance.[6]

[6] Note that the effect of Length of Residence in the Netherlands (LoRN) could not be investigated: LoRN had a positive correlation with Age of Adoption. $r_s = .475$, $p < .05$. LoRN also had a very strong positive correlation with Age, r = 951, $p < .05$, which was significantly negatively correlated with the adoptees'

Because AoA did not affect performance, it seems likely that the early adopted group should also outperform the Dutch control group. The following analyses investigated whether that was indeed the case. First, the early adopted group was compared to all Dutch controls, and next, the early adopted group was compared to subsets of the Dutch controls.

The early adopted group (containing participants who were adopted before five months of age, $N = 14$) was first compared with the entire Dutch control group ($N = 29$). The proportion of females was significantly higher in the early adopted group (13/14) than in the Dutch control group (16/29), $\chi^2(1) = 6.107$, $p < .05$. The two groups did not differ in any of the other control variables (Age, Visit, Visit Ratio, Schooling, Number of Languages), or in the results of the word recognition test. An ANCOVA was carried out across participants with the variables Test (pre-test, intermediate test, post-test), Place of articulation (alveolar, bilabial, velar), Target type (fortis, lenis, aspirated) and Group (early adopted, Dutch control). Sex was included as a covariate. Importantly, there was a significant main effect of Group, $F(1, 40) = 11.151$, $p < .05$, $\eta_p^2 = .218$, and a significant interaction between Group and Test, $F(2, 80) = 5.391$, $p < .05$, $\eta_p^2 = .119$. Further analysis showed that the early adopted group significantly outperformed the Dutch control group at each of the tests (pre-, intermediate, and post-tests).

In order to make certain that the difference between the early adopted group and the Dutch control group was not due to the unequal sample sizes (14 vs. 29) or unequal ratios of female to male participants (13/14 vs. 16/29), the same ANOVAs were repeated, now comparing the subgroup of early adoptees with similar sized subgroups of Dutch control participants, that were matched on all control variables. For that subgroup-analysis, 14 Dutch control participants were selected. In the first analysis, the control subgroup was chosen to

performance at the three tests (pre-test: $r = -0.617$, $p < .05$; intermediate test: $r = -0.431$, $p < .05$; post-test: $r = -0.513$, $p < .05$).

provide the best match on all of the control variables. In the second analysis, the control subgroup was chosen to include the participants with the best performance on the post-test (while keeping the number of males and females the same as in the early adopted group). In both cases, the early adopted group and the control subgroup did not significantly differ in any of the control variables (Sex, Age, Visit, Visit Ratio, Schooling, Number of Languages), or in the results of the word recognition test. Importantly, in both subgroup analyses, the results were similar to those comparing the early adoptees to the entire Dutch control group: Again, there was a significant main effect of group (the first subgroup-analysis: $F1(1, 26) = 4.440$, $p < .05$, $\eta_p^2 = .146$; $F2(1, 216) = 143.992$, $p < .05$, $\eta_p^2 = .400$; the second subgroup-analysis: $F1(1, 26) = 4.471$, $p < .05$, $\eta_p^2 = .147$; $F2(1, 216) = 146.755$, $p < .05$, $\eta_p^2 = .405$.), with the early adopted group outperforming the Dutch control subgroups.

Thus, all sub-group analyses showed consistent results. In line with the results of the partial correlation, these analyses confirm that, surprisingly, even less than six months of exposure to Korean in early life facilitated relearning of the Korean consonant contrasts several decades later. The early adopted group consistently performed better than the Dutch controls during the pre-, intermediate, and post-tests.

3.3.4 Homogeneity of Dutch control participants

As described in the General Method chapter, some of the Dutch control participants were related to Korean adoptees (i.e., they were either sibling or partner of a Korean adoptee). To assess if the presence or absence of such a relationship affected the Dutch control participants' performance, the control participants who were related to Korean adoptees ($N = 15$) were compared with the control participants who were not related to Korean adoptees ($N = 14$). An ANOVA was carried out across participants with the variables Test (pre-test, intermediate test, post-test), Place of articulation (alveolar, bilabial, velar), Target type (fortis, lenis, aspirated)

and Relationship to adoptees (related, unrelated). There were no significant effects of the Relationship to adoptees. The fact that the relationship to Korean adoptees did not affect the performance of the Dutch control participants confirms the validity of the control group. As mentioned in the Introduction (Chapter 1), siblings and partners of Korean adoptees were considered the optimal control group for this study, but due to the small size of that population, Dutch controls who were not related to Korean adoptees also had to be recruited. Importantly, the 'unrelated' Dutch controls showed similar results as the 'related' Dutch controls. Thus, the lack of 'related' controls did not lead to a less appropriate control group, but rather, the control group can be considered as suitable as a control group consisting entirely of Dutch controls who were related to Korean adoptees.

3.3.5 Korean control participants versus adoptees and Dutch control participants

The results of the native Korean control participants were analyzed, first to assess the quality of the stimuli and, second, to compare their performance with that of the adoptees and the Dutch controls. As Figure 3.4 shows, the native Korean control participants performed almost perfectly on each of the nine target sounds, confirming the validity of the stimuli.

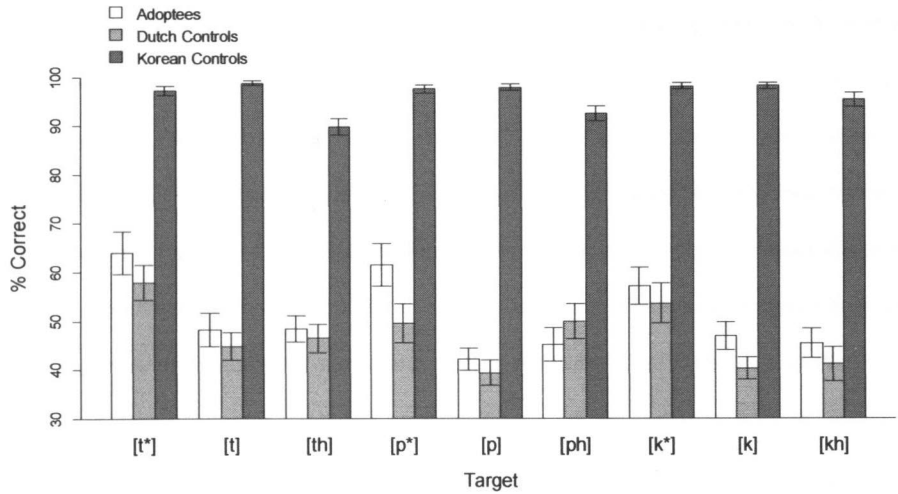

Figure 3.4. Percentage correct for Korean adoptees and Dutch controls at post-test, and for Korean controls (who participated in a single test session), separately per target consonant. Error bars represent standard errors.

The results of the Korean controls (who participated in a single test session) were compared to the post-test results of the adoptees and the Dutch control participants, in order to assess to what extent the adoptees and the Dutch control participants approached Korean native-like performance after extensive training. As Figure 3.4 shows, the Korean controls markedly outperformed the adoptees and the Dutch control participants for all the target consonants. ANOVAs were carried out across participants (*F1*) and across items (*F2*) with the variables Group (adoptee, Dutch control, Korean control), Place of articulation (alveolar, bilabial, velar), and Target type (fortis, lenis, aspirated). As expected, there was a significant main effect of Group, $F1(2, 80) = 182.924$, $p < .05$, $\eta_p^2 = .821$; $F2(2, 432) = 2131.845$, $p < .05$, $\eta_p^2 = .908$, as well as a significant three-way interaction between all the variables, $F1(8,320) = 2.299$, $p < .05$, $\eta_p^2 = .054$; $F2(8,432) = 2.429$, $p < .05$, $\eta_p^2 = .043$. To compare the performance of the Korean controls against the adoptees and against the Dutch controls, 18 *t*-

tests across participants and across items were carried out (9 target sounds * 2 groups), using Bonferroni correction. All the comparisons showed significant effects (Bonferroni corrected *p*s < .001). That is, the native Korean participants performed significantly better than the adoptees and the Dutch controls in all the target consonants. This shows that, not surprisingly, the training was not enough for the adoptees and the Dutch control participants to achieve native-like performance in recognizing Korean stop consonants.

3.4 Discussion

The present study has explored whether Korean adoptees in the Netherlands who had exposure to Korean only in early childhood performed better than native Dutch control participants when (re)learning parts of the Korean phoneme inventory later in life. The results show that the adoptees performed better than the controls in identifying Korean stop contrasts after perceptual training. The adoptees and controls performed equivalently in the pre-test, but, crucially, in the intermediate test, the adoptees outperformed the controls in identifying the Korean stop contrasts, both at trained and untrained places of articulation. In the post-test, the two groups performed similarly again. That is, the adoptees were faster than the Dutch controls to learn the contrast, and to generalize the learning to the similar contrasts at new places of articulation. The results thus show that phonological knowledge gained in infancy persists into adulthood despite a lack of usage over several decades, and the persisting knowledge confers an advantage in relearning the birth-language phonology later in life.

For the adoptees and the Dutch controls alike, there was significant improvement on the identification of the Korean contrasts, with more improvement for the trained contrast than the untrained contrasts. The fact that there was measurable learning and generalization in both groups confirms the validity of our training and testing methods. Also, the validity of the

testing stimuli was confirmed by the finding that the native Korean controls performed almost perfectly on all targets.

For the Dutch control group, the presence or absence of a relationship to Korean adoptees did not affect the controls' performance. The Dutch controls who were either siblings or partners of Korean adoptees were assumed to be the optimal control population for this study because they might be most similar to the adoptees in socio-economic background, interest in Korean, and possibly, level of motivation for participation. Due to the difficulty of recruiting that population, however, further Dutch control participants who were not related to Korean adoptees also had to be recruited. Note that more than half of the 'unrelated' control participants (8/14 participants) had been to Korea, so that possibly they were interested in Korean. Importantly, the 'unrelated' Dutch controls performed as well as the 'related' Dutch controls. This thus suggests that our Dutch control group can be considered as appropriate as a control group which consists entirely of Dutch controls who were related to Korean adoptees.

Within the adoptee group, surprisingly, there was no effect of age of adoption on performance. There were no significant partial correlations between age of adoption and the adoptees' performance at any of the three tests. Further, there was no difference in performance between the adoptees who were adopted before five months of age and the adoptees who were adopted after 17 months of age. That is, after many years of non-exposure to Korean, the length of exposure to Korean in early years did not play a significant role to explain the adoptees' performance. Note that the adoptees' length of residence in the Netherlands was over 23 years for all adoptees (see Chapter 2.1). The long time that had elapsed since their adoption might have washed out any possible effects of age of adoption.

In line with the results about the age of adoption above, a subgroup consisting of the adoptees adopted between three to five months of age also outperformed the Dutch controls.

This clearly demonstrates that although those adoptees' exposure to their birth language was limited to only a few months from birth, it facilitated relearning of phonemes of this language several decades later. The result that the relearning advantage occurred for adoptees who were adopted between three and five months of age is intriguing, because empirical evidence suggests that at that age, infants' acquisition of the native phonology has yet to emerge — only from six months does infants' phoneme perception begin to be adjusted to the native language (Kuhl, 2004; Werker & Tees, 1984). There are, however, also converging lines of evidence suggesting that infants younger than five months are likely to have obtained substantial knowledge of their native phonology. First, it has been shown that neonates can encode, retain, and retrieve auditory information using the left temporal and right frontal cortex (Benavides-Varela et al., 2012). The cortical areas are involved in auditory memory in adults, indicating that an adult-like memory system is already functional from birth. Indeed, auditory memory processing in two- to three-month-old infants resembles that in adults (Dehaene-Lambertz, Dehaene, & Hertz-Pannier, 2002). Second, it has been shown that neonates' brain activity increases when there is a change in the phonemic category of syllables they hear, which is evidence for phonemic information processing at birth (Dehaene-Lambertz & Peña, 2001). Analogously, another study in three-month-old infants shows brain activation for a change in phonemic category (Dehaene-Lambertz & Baillet, 1998). Taken together, the previous studies suggest that five-month-olds do not yet have a fully-fledged phonological system in place, but are already in the process of acquiring it. The results from the present study suggest that adoptees' experience with Korean for three to five months from birth was sufficient to leave a lasting knowledge about Korean phonemes.

Comparing all adoptees and Dutch controls, the results showed no difference between the two groups at the pre-test, before training. This is in line with previous studies, where a test was conducted without a re-exposure phase, and adult adoptees failed to show any

remaining knowledge of their birth language (Pallier et al., 2003; Ventureyra et al., 2004). In contrast, however, the adoptees who were adopted before five months of age performed better than the Dutch controls from the pre-test. It is not clear what caused the discrepancy. A possible explanation is that the early adopted group might, by chance, have contained more participants who were talented at language than the late adopted group. Another possibility is that it might be due to attitudinal reasons: Because they were adopted when very young, the early adoptees might have experienced less psychological difficulty in adapting to their new environment post-adoption than the late adoptees. This could have helped the early adoptees to develop a more comfortable attitude to their adoption than the late adoptees, making them more receptive to increasing knowledge of their birth language. These suggestions are, however, purely speculative and there is as yet no clear explanation for the pattern of results.

4 Production of Korean stops

4.1 Introduction

In the experiment of the previous chapter, the Korean adoptees relearned to identify the Korean consonant contrasts better than the Dutch control participants. This finding demonstrates that phonological knowledge of the birth language, which was acquired in infancy, remained into adulthood, even if actual experience with the language had ended several decades ago.

In the previous chapter, the relearning benefit of adoptees' early experience was explored in the domain of speech perception; the present study is aimed at examining such benefit in the domain of speech production. The critical question is whether the Korean adoptees produce Korean consonants in a more native-like manner than the Dutch control participants, as a result of the perceptual training on the consonants.

There are a few studies investigating benefits of early exposure to a language for production later in life, all investigating heritage languages rather than international adoptees' birth language. Participants in those studies were immigrants or had one or more parents or relatives who were immigrants (Au et al., 2002; Knightly et al., 2003; J. S. Oh et al., 2003). They were regularly exposed to the heritage language during their early years, but at some point during childhood, the amount of exposure became considerably reduced. Those studies showed that when participants who had been exposed to the heritage language during

childhood relearned that language, they produced phonemes of the language in a more native-like manner than naïve learners (Au et al., 2002; Knightly et al., 2003; J. S. Oh et al., 2003). A crucial difference from the present study is that the participants in those studies, unlike the adoptees in the present case, had maintained continuous contact with their childhood language, as in most cases they lived in a community using that language. To the best of our knowledge, the present study is the first to investigate the production benefits in international adoptees, whose contact with the birth language was entirely lost many years ago.

It has been shown that training participants to identify a difficult non-native contrast can lead to improvement in production of the contrast too (Bradlow et al., 1999; Bradlow et al., 1997). Therefore, we expected to find a measurable improvement in production of the Korean contrasts following the perceptual training, and we did not include training on production. Importantly, if the relearning benefit is not limited to perception, the improvement might be bigger for the adoptees than for the Dutch controls.

The present study investigated the same Korean adoptees and Dutch control participants described in the General Method (Chapter 2). In the study described in Chapter 3, the adoptees and Dutch controls were trained to perceive the Korean three-way alveolar stop contrast. In the present study, the relearning benefit on production is examined by comparing the adoptees' and the Dutch controls' improvement in pronunciation of the alveolar, bilabial, and velar contrasts following this perceptual training. We collected productions of the consonants by the adoptees and Dutch controls at pre- and post-tests, and of Korean controls at a single test session (Experiment 1). The produced utterances were evaluated by native listeners of Korean, with a phoneme identification task (Experiment 2), and with a phoneme rating task (Experiment 3). If adoptees' early language experience gives them a relearning benefit in the domain of speech production (similar to that found in the domain of speech

perception), the adoptees might produce more native-like Korean consonants than the Dutch control participants.

4.2 Experiment 1: Production tests

4.2.1 Method

4.2.1.1 Participants

The same 83 participants as described in the General Method (Chapter 2) — 29 Korean adoptees, 29 native Dutch control participants, and 25 native Korean control participants — took part.

4.2.1.2 Materials

The crucial phonemes were again the Korean fortis, lenis, and aspirated stops. During the tests, participants produced them at three places of articulation: alveolar [t*, t, t^h], bilabial [p*, p, p^h], and velar [k*, k, k^h]. For each of the alveolar, bilabial, and velar places of articulation, three minimal triplets of consonant-vowel (CV) Korean pseudowords were created (Table 4.1). Within each triplet, items varied only in fortis, lenis, and aspirated stops. Each triplet contained the vowel [a], [i], or [u].

Table 4.1. Minimal triplets of Korean pseudowords

Place of articulation	Fortis	Lenis	Aspirated
Alveolar	[t*a]	[ta]	[t^ha]
	[t*ɪ]	[ti]	[t^hi]
	[t*u]	[tu]	[t^hu]
Bilabial	[p*a]	[pa]	[p^ha]
	[p*i]	[pi]	[p^hi]
	[p*u]	[pu]	[p^hu]
Velar	[k*a]	[ka]	[k^ha]
	[k*i]	[ki]	[k^hi]
	[k*u]	[ku]	[k^hu]

A 34 years old female native speaker of Seoul Korean who did not record any materials for the training or the identification test in Chapter 3 recorded multiple tokens of all 27 items; nine tokens of each item (a total of 243 tokens) were selected. Items were recorded and processed in the same way as described in the General Method (Chapter 2).

4.2.1.3 Procedure

As part of the multi-session training and testing sequence, Korean adoptees and native Dutch control participants performed two production tests, namely a pre-test after the first training block (after the perception pre-test), and a post-test after the 13th training block (after the perception post-test), while the Korean control participants took part in one test (with no training) (see Chapter 2 for details).

A repetition task was used. Participants read a written instruction that at each trial they would hear a one-syllable stimulus. They were asked to repeat the stimulus aloud immediately after the stimulus was presented. Each trial started with a fixation mark on the

computer screen for 200 ms, followed by auditory presentation of the stimulus. Participants had 2,000 ms to respond.

Stimuli were blocked by place of articulation, manner of articulation, and vowel, as indicated in Table 4.2. Each block contained three tokens of the same stimulus. Stimuli were presented in three series of the 27 blocks, in a fixed order for all participants. Participants finished all three series for one place of articulation (nine blocks) before moving on to the next place of articulation. After every three blocks, participants had the option to take a short break. Before every three blocks, participants were informed whether they were going to hear fortis, lenis, or aspirated stops by presentation on the screen of symbols which were introduced to the participants during the perception training.

4.2.2 Selection

For each participant, for each test, and for each of the 27 CV items, one token was selected for use in Experiment 2 and 3, with a total of 3807 tokens (27 items * [(29 adoptees * 2 tests) + (29 Dutch controls * 2 tests) + (25 Korean controls * 1 test)]). For each item, the last token from the second series was selected, or, if the sound quality of that token was poor due to background noise or clipping distortion, the last token from the third series was selected (128 tokens; 3.4% of all tokens). When both tokens were poor, the first token from the third series was selected (10 tokens; 0.3% of all tokens).

Table 4.2. Composition and order of the twenty-seven blocks for the repetition task

Block	Place of articulation	Manner of articulation	Vowel
1			/a/
2		Fortis /t*/	/i/
3			/u/
4			/a/
5	Alveolar	Lenis /t/	/i/
6			/u/
7			/a/
8		Aspirated /t^h/	/i/
9			/u/
10			/a/
11		Fortis /p*/	/i/
12			/u/
13			/a/
14	Bilabial	Lenis /p/	/i/
15			/u/
16			/a/
17		Aspirated /p^h/	/i/
18			/u/
19			/a/
20		Fortis /k*/	/i/
21			/u/
22			/a/
23	Velar	Lenis /k/	/i/
24			/u/
25			/a/
26		Aspirated /k^h/	/i/
27			/u/

4.3 Experiment 2: Korean listeners' phoneme identification

4.3.1 Method

4.3.1.1 Participants

Thirty native speakers of Korean (eight female, 22 male, M_{age} = 23.67 years, range: 19-36 years) were recruited from the student population of Hanyang University in Seoul, South Korea. The participants received a monetary reward for their participation.

4.3.1.2 Materials

The 3807 tokens selected in Experiment 1 were arranged into three sets (1269 tokens per set); the first set contained the tokens with the vowel [a], the second with [i], and the third with [u]. Each set thus contained all nine target stops from all speakers, and from each test (pre- and post-tests for the adoptees and Dutch controls, and a single test for the Korean controls).

4.3.1.3 Procedure

A three-alternative forced-choice identification task was used. Participants were randomly assigned to one of the three sets (with /a/, /i/, or /u/), with 10 participants per set. Each set consisted of three blocks; the first block contained the alveolars, the second the bilabials, and the third the velars. Within each block, stimuli were presented in a random order, and between blocks, there was a short break. The experiment started with a written instruction, followed by six practice trials and the main test phase.

In the instruction, participants were informed that on each trial they would hear a CV stimulus. They were asked to listen carefully to the consonant of the stimulus and to decide which of the three target consonants for that block it was. They gave their responses by pressing the keys 1, 2, or 3, for all blocks, representing 1: lenis, 2: fortis, and 3: aspirated.

Before each block, participants were informed which consonants were the three targets for that block (e.g., /t*, t, t^h/ for the first block), and which target consonant corresponded to each response key.

Each trial started with a black screen for 600 ms, followed by auditory presentation of the stimulus, and presentation of three alternatives in Korean orthography on the computer screen. Participants had 10,000 ms to respond.

The practice trials contained unique tokens, from six of the 83 speakers.

The participants were seated in front of a computer in a quiet room. They heard the auditory materials through high quality headphones. Responses were given by pressing keys on the computer keyboard. The experiment lasted approximately 35 minutes. Presentation software (Version 14.7. Neurobehavioral Systems Inc.) was used for setting up and running the experiment.

4.3.2 Results

First, and importantly, we explore whether the native listeners of Korean categorized the utterances of the adoptees more accurately than those of the Dutch controls. Second, the identification of the trained alveolar stops is compared with that of the untrained bilabial and velar stops. Third, it is examined whether age of adoption affects the adoptees' production. Fourth, it is examined whether presence or absence of a relationship with a Korean adoptee affects the Dutch control participants' production. Finally, the utterances of the Korean controls (who participated in a single test session) are compared with those of the adoptees and the Dutch controls at the post-test.

For all analyses, proportions of correct identification by native listeners of Korean were used as dependent variable. Ninety-two responses with reaction times longer than

10,000 ms (0.24% of all responses) were considered as outliers and excluded from analysis, and 34 responses were excluded due to technical errors (0.09% of all responses).

4.3.2.1 Adoptees versus Dutch control participants

First, it was examined whether the utterances produced by the adoptees were identified more accurately than those produced by the Dutch controls.

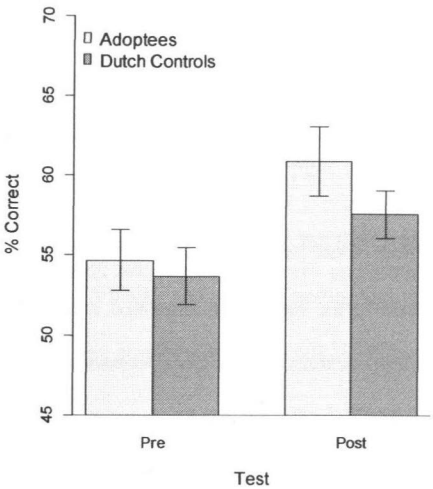

Figure 4.1. Percentage correct for native Korean listeners' identification of pre-test and post-test productions (across all three places of articulation) from Korean adoptees and Dutch controls. Error bars represent standard errors.

Figure 4.1 shows that the native Korean listeners identified the utterances from the adoptees more accurately than those from the Dutch controls at the post-test. For the adoptees and Dutch controls alike, post-test productions were more accurately identified than pre-test productions. An ANOVA was carried out across Korean listeners with the within-subject variables Speaker group (adoptee, Dutch control), Test (pre-test, post-test), Place of articulation (alveolar, bilabial, velar), and Manner of articulation (fortis, lenis, aspirated) and

the between-subject variable Vowel (/a/, /i/, /u/). Indeed, there were significant main effects of Speaker group, $F(1, 27) = 28.205$, $p < .05$, $\eta_p^2 = .511$, and of Test, $F(1, 27) = 170.732$, $p < .05$, $\eta_p^2 = .863$, and a significant interaction between Speaker group and Test, $F(1, 27) = 5.062$, $p < .05$, $\eta_p^2 = .158$. There was also a significant five-way interaction among all variables, $F(8, 108) = 4.371$, $p < .05$, $\eta_p^2 = .245$. Further analyses confirmed that for the pre-test utterances, there was no difference between the adoptees and the Dutch controls but, crucially, for the post-test, utterances from the adoptees were significantly more accurately identified than those from the Dutch controls, $F(1, 27) = 22.686$, $p < .05$, $\eta_p^2 = .457$. Both for the adoptees and Dutch controls, the identification accuracy was better for the post-test than for the pre-test production (adoptee: $F(1, 27) = 114.416$, $p < .05$, $\eta_p^2 = .809$; Dutch control: $F(1, 27) = 32.939$, $p < .05$, $\eta_p^2 = .55$).

In sum, as a result of the perceptual training, there was improvement in both the adoptees' and Dutch controls' articulation of Korean fortis, lenis, and aspirated stops, but, importantly, the improvement was greater for the adoptees than for the Dutch controls. Thus, the adoptees showed a relearning benefit in the domain of production too.

4.3.2.2 Trained versus untrained places of articulation

Recall that in the perceptual identification training (Chapter 2), participants were trained with only alveolar stops. It was explored whether the improvement in pronunciation differed between the trained alveolar and the untrained bilabial and velar stops.

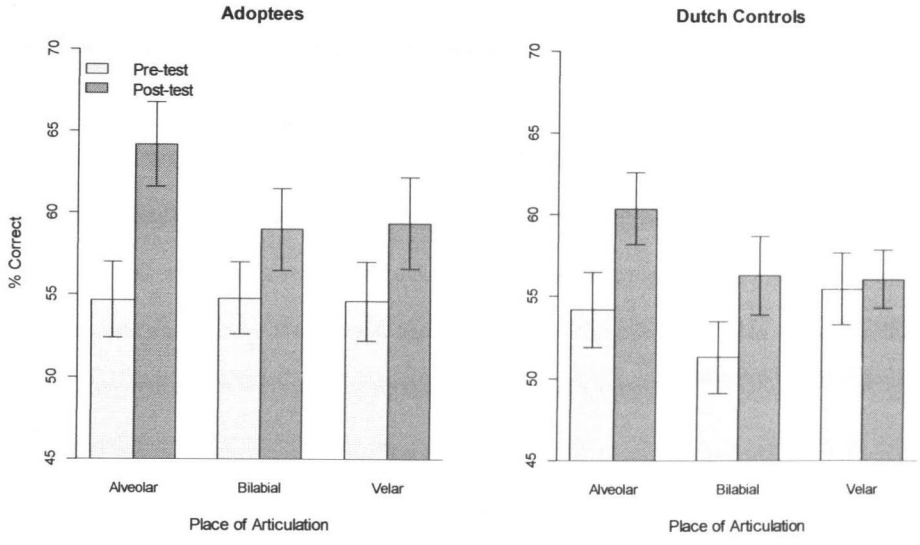

Figure 4.2. Percentage correct for native Korean listeners' identification of pre-test and post-test productions from Korean adoptees and Dutch controls, separately for the trained alveolars and the untrained bilabials and velars. Error bars represent standard errors.

Figure 4.2 shows that improvement was greater for productions of the trained alveolar stops than those of the untrained bilabial and velar stops for both groups. For the pre-test utterances, there was no significant difference in the identification accuracy among the alveolar, bilabial, and velar stops, but for the post-test utterances, the accuracy was higher for the trained stops (alveolar) than for the untrained stops (bilabial and velar) (alveolar vs. bilabial for adoptees: $F(1, 27) = 28.549$, $p < .05$, $\eta_p^2 = .514$; alveolar vs. velar for adoptees: $F(1, 27) = 24.090$, $p < .05$, $\eta_p^2 = .472$; alveolar vs. bilabial for controls: $F(1, 27) = 15.742$, $p < .05$, $\eta_p^2 = .368$; alveolar vs. velar for controls: $F(1, 27) = 21.988$, $p < .05$, $\eta_p^2 = .449$). Further, for each place of articulation, the post-test utterances were identified significantly more accurately than the pre-test utterances for both groups ($ps < .001$) (with one exception[7]).

[7] There was no significant difference between the pre-test and post-test utterances of the Dutch controls for the velar stops.

Similarly, for each manner of articulation, the accuracy was significantly better for the post-test productions than for the pre-test productions for both groups (*p*s < .05) (again with one exception[8]).

In summary, pronunciation improved for both the trained alveolar and the untrained bilabial and velar stops, but the improvement was bigger for the trained stops than for the untrained stops, both for the adoptees and for the Dutch controls.

4.3.2.3 Age of adoption

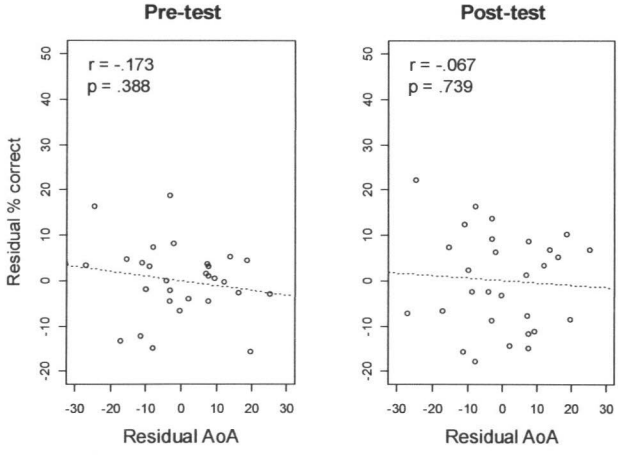

Figure 4.3. Partial regressions between Age of Adoption (AoA) and proportion correct for native Korean listeners' identification of pre-test and post-test productions (across all three places of articulation) from Korean adoptees; the X-axis represents the residuals of the regression of the AoA on Age and Sex; the Y-axis represents the residuals of the regression of the identification accuracy on Age and Sex; lines represent regression coefficients.

It was investigated whether Age of Adoption (AoA) influenced how accurately the adoptees produced the Korean stops (Figure 4.3): Partial correlations were carried out between AoA and the identification accuracy for the adoptees' pre-test and post-test productions, while controlling for the effect of Age and Sex (which were highly correlated with AoA; see

[8] There was no significant difference between the pre-test and post-test utterances of the Dutch controls for the fortis stops.

Chapter 3.3.3 for more details). Neither the pre-test nor the post-test production was significantly correlated with AoA (at pre-test: r = -.173, p = .388; at post-test: r = -.067, p = .739).

To further investigate to what degree AoA, Age, and Sex affected the adoptees' productions, two multiple regression analyses were undertaken with AoA, Age, and Sex as predictors, and with the identification accuracy for the adoptees' utterances as dependent variables: one analysis for the pre-test and the other for the post-test. Table 4.3 shows that none of the predictors significantly contributed to either of the models.

Thus, the partial correlations and multiple regressions consistently showed that AoA did not influence the adoptees' articulation of the Korean stops.

Table 4.3. Multiple regression analyses predicting proportion correct for native Korean listeners' identification of pre-test and post-test productions (across all three places of articulation) from Korean adoptees

	Pre-test R^2 = 658			Post-test R^2 = .459		
Variable	*B*	*SE B*	*t*(25)	*B*	*SE B*	*t*(25)
Constant	.716	.115	6.212*	.734	155	4.726*
Age of Adoption	-.001	001	-0.878	-.001	002	-0 336
Age	-.008	.004	-1.936	- 007	005	-1 244
Sex	.059	045	1.293	.059	061	0.957

*p < .05.

4.3.2.4 Homogeneity of Dutch control participants

Half of the Dutch control participants were either siblings or partners of a Korean adoptee. As in Chapter 3, we examined whether the Dutch controls who had such a relationship performed better than those who had no relationship with a Korean adoptee. An ANOVA was carried out across Korean listeners on the identification scores of the Dutch controls only.

with the within-subject variables Relationship to adoptees (related, unrelated), Test (pre-test, post-test), Place of articulation (alveolar, bilabial, velar), and Manner of articulation (fortis, lenis, aspirated) and the between-subject variable Vowel (/a/, /i/, /u/). There was a significant five-way interaction among all variables, $F(8, 108) = 12.804$, $p < .05$, $\eta_p^2 = .487$. Follow-up analyses showed that for the pre-test utterances, there was no difference between the related and unrelated groups, but for the post-test utterances, the identification accuracy was better for the unrelated group than for the related group, $F(1, 27) = 7.146$, $p < .05$, $\eta_p^2 = .209$; further analyses showed that the results patterned this way only for (untrained) bilabial stops, $F(1, 27) = 32.452$, $p < .05$, $\eta_p^2 = .546$.

In short, the presence of a relationship to a Korean adoptee did not lead to *better* performance of the Dutch control participants (and even to poorer performance in some conditions), confirming the validity of the choice of control participants.

4.3.2.5 Korean control participants versus adoptees and Dutch control participants

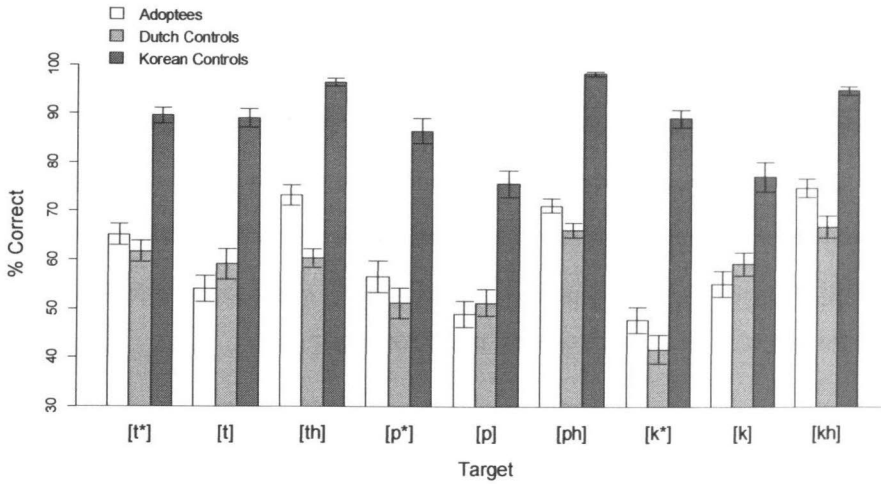

Figure 4.4. Percentage correct for native Korean listeners' identification of post-test productions from Korean adoptees and Dutch controls and of productions from Korean controls, separately per target consonant. Error bars represent standard errors.

The native Korean listeners' identification of the utterances from the Korean controls (who participated in a single test session) was compared with their identification of the utterances from the adoptees and the Dutch controls at post-test. As Figure 4.4 shows, not surprisingly, the identification accuracy was markedly greater for the utterances produced by the Korean controls than for those produced by the other two groups, for all target consonants.

An ANOVA was carried out across Korean listeners with the within-subject variables Speaker group (adoptee, Dutch control, Korean control), Place of articulation (alveolar, bilabial, velar), and Manner of articulation (fortis, lenis, aspirated) and the between-subject variable Vowel (/a/, /i/, /u/). As expected, there was a significant main effect of Group, $F(2, 54) = 1104{,}959$, $p < .05$, $\eta_p^2 = .976$. There was also a significant four-way interaction among all the variables, $F(16,216) = 5.150$, $p < .05$, $\eta_p^2 = .276$. To compare the identification

accuracy for the productions from the Korean controls with that of the adoptees and the Dutch controls, 18 *t*-tests across participants were carried out (9 target consonants * 2 speaker groups), using Bonferroni correction. All the comparisons showed significant effects (Bonferroni corrected *p*s < .001). That is, for all target consonants, the Korean controls' productions were significantly more accurately categorized than the adoptees' and the Dutch controls' post-test productions. This shows that the training was not enough for the adoptees and Dutch controls to produce the target consonants in a Korean native-like way.

4.4 Experiment 3: Korean listeners' phoneme ratings

4.4.1 Method

4.4.1.1 Participants

Thirty native speakers of Korean (eight female, 22 male, M_{age} = 23.87 years, range: 19-30 years) were recruited from the student population of Hanyang University. None of them had participated in Experiment 2. The participants received a monetary reward for their participation.

4.4.1.2 Materials

The same three sets were used as in Experiment 2 (containing [a], [i], and [u], respectively).

4.4.1.3 Procedure

A rating task was used. Equal numbers of participants were randomly assigned to each of the three sets. Each set consisted of nine blocks for the nine target stops [t], [t*], [t^h], [p], [p*], [p^h], [k], [k*], and [k^h], always in that order. The experiment started with written instructions, followed by 10 practice trials and the nine experimental blocks.

Participants were informed that on each trial they would hear a CV stimulus. They were asked to focus on the consonant, to disregard the vowel and the recording quality, and to decide how well the consonant represented the target consonant given for that block. They were asked to rate the pronunciation of the consonant on a four-point scale, as: 1 (very good), 2 (good), 3 (poor), 4 (very poor). Participants were encouraged to use the full scale. Before each block, participants were informed which consonant was the target for that block.

Each trial started with a black screen for 600 ms, after which the four-point scale and the orthographic representation of the target consonant appeared on the computer screen, and the auditory stimulus was played.

All else was similar to the procedure in Experiment 2.

4.4.2 Results

For all analyses, rating scores were used as dependent variable. Forty-six responses with reaction times longer than 10,000 ms (0.12% of all responses) were considered as outliers and excluded from analysis, and 10 responses were excluded due to technical errors (0.03% of all responses).

4.4.2.1 Adoptees versus Dutch control participants

First, we investigated whether the utterances produced by the adoptees received better ratings than those produced by the Dutch controls.

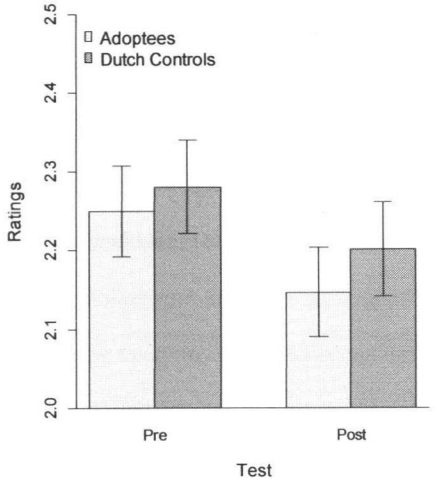

Figure 4.5. Ratings by native Korean listeners for pre-test and post-test productions from Korean adoptees and Dutch controls (across all three places of articulation) (from 1 = "very good" to 4 = "very poor"). Error bars represent standard errors.

As Figure 4.5 shows, the results were similar to those of Experiment 2 (but note that lower scores here reflect more positive ratings): the native Korean listeners' ratings were more positive for the adoptees than for the Dutch controls at the post-test, while there was no substantial difference between the adoptees and Dutch controls at the pre-test.

An ANOVA across Korean listeners was carried out with the within-subject variables Speaker group (adoptee, Dutch control), Test (pre-test, post-test), Place of articulation (alveolar, bilabial, velar), and Manner of articulation (fortis, lenis, aspirated), and the between-subject variable Vowel (/a/, /i/, /u/), and showed significant main effects of Speaker group, $F(1, 27) = 9.564$, $p < .05$, $\eta_p^2 = .262$, and of Test, $F(1, 27) = 119.240$, $p < .05$, $\eta_p^2 = .815$, and a significant five-way interaction with all variables, $F(8, 108) = 3.302$, $p < .05$, $\eta_p^2 = .197$. Following up on that interaction, simple main effects showed that, in line with Figure 4.5, the adoptees received significantly better ratings than the Dutch controls for the

utterances from the post-test, $F(1, 27) = 13.427$, $p < .05$, $\eta_p^2 = .332$, whereas the adoptees and Dutch controls received similar ratings for the utterances from the pre-test. For both groups, the post-test productions received better ratings than the pre-test productions (adoptee: $F(1, 27) = 104.638$, $p < .05$, $\eta_p^2 = .795$; Dutch control: $F(1, 27) = 39.049$, $p < .05$, $\eta_p^2 = .591$).

Thus, consistent with Experiment 2, the adoptees' and the Dutch controls' pronunciation of the Korean stops improved from the pre-test to the post-test but, crucially, the improvement was larger for the adoptees than for the Dutch controls.

4.4.2.2 Trained versus untrained places of articulation

Next, we explored whether the improvement in the ratings differed between the trained alveolar and the untrained bilabial and velar stops.

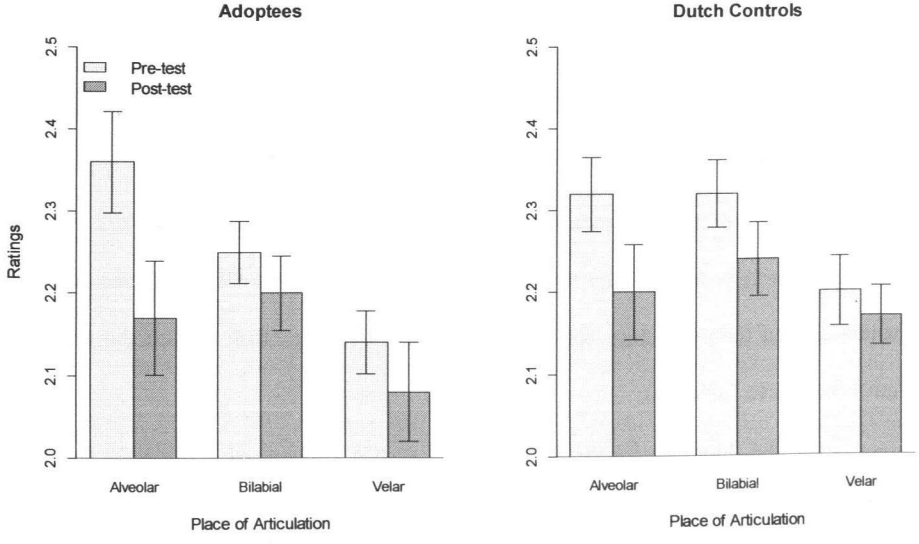

Figure 4.6. Ratings by native Korean listeners for pre-test and post-test productions from Korean adoptees and Dutch controls, separately for the trained alveolars and the untrained bilabials and velars (from 1 = "very good" to 4 = "very poor"). Error bars represent standard errors.

Figure 4.6 shows that, as in Experiment 2, the improvement in the ratings was larger for the trained alveolar stops than for the untrained bilabial and velar stops, for both groups. Consistently, partial eta squared (η_p^2) indicated that the effect size of the improvement was larger for the trained alveolar stops than for the untrained bilabial and velar stops, for both groups (Table 4.4). To further explore this pattern, four separate ANOVAs were undertaken, each one comparing the trained alveolar stops with either the bilabial stops or the velar stops, separately for both speaker groups, with the within-subject variables Test (pre-test, post-test), Place of articulation (two places per analysis), and Manner of articulation (fortis, lenis, aspirated), and the between-subject variable Vowel (/a/, /i/, /u/). Indeed, there was a significant interaction between Test and Place of articulation for three of the analyses confirming that improvement was larger for the trained than for the untrained stops (alveolar vs. bilabial for adoptees: $F(1, 27) = 31.26049$, $p < .05$, $\eta_p^2 = .537$; alveolar vs. velar for adoptees: $F(1, 27) = 22.323$, $p < .05$, $\eta_p^2 = .453$; alveolar vs. velar for controls: $F(1, 27) = 11.175$, $p < .05$, $\eta_p^2 = .293$); the difference did not reach significance for the alveolar versus bilabial stops for the Dutch controls.

For each place of articulation, for each group, the post-test utterances received significantly more positive ratings than the pre-test utterances ($ps < .001$), with one exception (namely that of the velar stops for Dutch controls, where the effect of Test did not reach significance) (see Table 4.4).

Note that unlike in Experiment 2, where effects of place of articulation showed a similar pattern for the two groups, and were only significant at the post-test and not at the pre-test, here, the effects of place of articulation were more variable, and already present at the pre-test[9].

[9] For the adoptees, at the pre-test: alveolar > bilabial > velar; at the post-test: bilabial > velar. For the Dutch controls, at the pre-test: alveolar > velar, and bilabial > velar; at the post-test: bilabial > velar ($ps < .05$). (Higher scores reflect more negative ratings.)

Thus, although less robust than in Experiment 2, the improvement in the ratings was generally greater for the trained alveolar stops than for the untrained bilabial and velar stops, for both the adoptees and the Dutch controls.

Table 4.4. Statistics for the simple main effects of Test (pre-test vs. post-test), for each place of articulation, separately for the adoptees and Dutch controls

	Adoptees		Dutch controls	
Place of articulation	$F(1, 27)$	η_p^2	$F(1, 27)$	η_p^2
(Trained) Alveolar	116.603*	.812	28.958*	.517
(Untrained) Bilabial	11.067*	.291	16.928*	.385
(Untrained) Velar	11.214*	.293	2.21	.076

*$p < .05$.

4.4.2.3 Age of adoption.

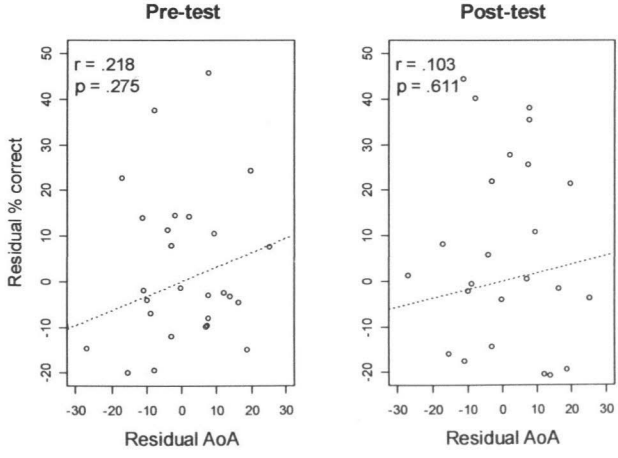

Figure 4.7. Partial regressions between Age of Adoption (AoA) and ratings for Korean adoptees' production on pre-, and post-tests (across all three places of articulation); the X-axis represents the residuals of the regression of the AoA on Age and Sex; the Y-axis represents the residuals of the regression of the ratings on Age and Sex; lines represent regression coefficients.

As in Experiment 2, the effect of AoA on the adoptees' productions was investigated (Figure 4.7). First, partial correlations were calculated between AoA and the ratings for the adoptees'

productions at the pre-test and post-test, while controlling for the effect of Age and Sex. In accordance with Experiment 2, the partial correlations showed no significant correlations between AoA and the ratings (at pre-test: $r = .218$, $p = .275$; at post-test: $r = .103$, $p = .611$). Second, multiple regression analyses on the ratings for the adoptees' productions at the pre-test and post-test, with AoA, Age, and Sex as predictors showed that, as in Experiment 2, AoA did not significantly contribute to the models (Table 4.5).

The results again suggest that AoA had no effect on the degree of success with which the adoptees articulated the target stops.

Table 4.5. Multiple regression analyses predicting ratings of pre-test and post-test productions from Korean adoptees (across all three places of articulation)

	Pre-test $R^2 = .304$			Post-test $R^2 = .231$		
	B	*SE B*	*t*(25)	*B*	*SE B*	*t*(25)
Constant	1.756	272	6.463*	1.369	.349	3.920*
Age of Adoption	.003	003	1.117	.002	.004	0.516
Age	.013	.010	1.411	.020	.012	1.641
Sex	.000	107	-0.001	.058	.138	0.425

*$p < .05$.

4.4.2.4 Homogeneity of control participants

To explore whether the presence or absence of a relationship with a Korean adoptee affected the performance of the Dutch controls, an ANOVA was carried out on the ratings of the Dutch controls only, with the within-subject variables Relationship to adoptees (related, unrelated), Test (pre-test, post-test), Place of articulation (alveolar, bilabial, velar), and Manner of articulation (fortis, lenis, aspirated) and the between-subject variable Vowel (/a/, /i/, /u/). Results were consistent with Experiment 2: There was a significant five-way interaction among all variables, $F(8, 108) = 10.468$, $p < .05$, $\eta_p^2 = .437$. For the pre-test utterances, there

was no difference between the 'related' and the 'unrelated' groups, but for the post-test utterances, the 'unrelated' group received significantly better ratings than the 'related' group, $F(1, 27) = 9.548$, $p < .05$, $\eta_p^2 = .261$; this pattern was observed for the bilabial and velar stops, but was significant only for the bilabial stops, $F(1, 27) = 21.227$, $p < .05$, $\eta_p^2 = .440$.

Thus, in line with Experiment 2, the Dutch controls who were related to a Korean adoptee did not perform *better* (but in some conditions even more poorly) than those who did not have such a relationship, confirming the validity of the control group.

4.4.2.5 Korean control participants versus adoptees and Dutch control participants

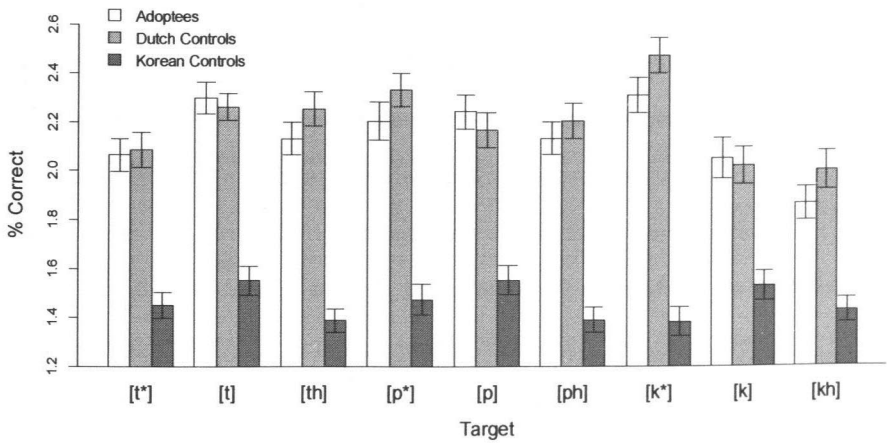

Figure 4.8. Ratings by native Korean listeners for post-test productions from Korean adoptees and Dutch controls, and of productions from Korean controls, separately per target consonant. Error bars represent standard errors.

The production ratings given to the Korean controls (who participated in a single test session) were compared with those of the adoptees' and the Dutch controls' post-test productions. Figure 4.8 shows that ratings were much lower (i.e., much more positive) for the Korean controls than for the adoptees and Dutch controls, for all target consonants.

Indeed, an ANOVA across Korean listeners with the within-subject variables Speaker group (adoptee, Dutch control, Korean control), Place of articulation (alveolar, bilabial, velar), and Manner of articulation (fortis, lenis, aspirated) and the between-subject variable Vowel (/a/, /i/, /u/) showed a significant main effect of Group, $F(2, 54) = 283.064$, $p < .05$, $\eta_p^2 = .913$; in addition, it revealed a significant four-way interaction among all variables, $F(16, 216) = 3.891$, $p < .05$, $\eta_p^2 = .224$. The ratings of the productions from the Korean controls were compared with those from the adoptees and the Dutch controls with 18 *t*-tests across participants (9 target consonants * 2 speaker groups), using Bonferroni correction. All comparisons were significant (Bonferroni corrected $ps < .001$), showing that the ratings of the utterances produced by the Korean controls were significantly more positive than those of the utterances produced by the adoptees and Dutch controls at the post-test, for all target consonants. This confirms the findings from Experiment 2 that, not surprisingly, the adoptees and Dutch controls did not produce native-like Korean consonants even after the perceptual training.

4.5 Discussion

The present study has investigated whether the adoptees' relearning benefits that were observed in the domain of speech perception (Chapter 3) also exist in the domain of speech production. The two evaluation tests carried out by native listeners of Korean, namely the phoneme identification (Experiment 2) and the phoneme rating task (Experiment 3), provided converging evidence that there were indeed such relearning benefits for adoptees in the domain of speech production. The Korean adoptees produced the Korean three-way stop contrasts more accurately than the Dutch control participants as a result of perceptual training on the contrasts. Both the adoptees and Dutch controls showed improvement in articulation of the Korean stops following the perceptual training, but, crucially, the improvement was

greater for the adoptees than for the Dutch controls. This finding demonstrates that the phonological knowledge of the birth language that the adoptees gained in their early years is beneficial not only for their perception but also for their production of birth language phonemes.

Surprisingly, but in line with Chapter 3, duration of exposure to Korean in the early years did not affect the adoptees' performance in the present study. In both the identification and rating tests, there were no significant correlations between age of adoption and the native Korean listeners' evaluations of the adoptees' articulation; similarly, the multiple regression analyses showed no effect of age of adoption on those evaluations. That is, as in the perception domain (Chapter 3), the duration of childhood experience with the birth language did not explain how well the adoptees produced the birth-language sounds in adulthood.

In order to assess the validity of the Dutch control group, it was explored whether those who did not have any relationship with a Korean adoptee performed more poorly than those who were either sibling or partner of a Korean adoptee, and who were deemed the ideal control group. The results from both tests consistently showed that the 'unrelated' controls did not lag behind the 'related' controls; to the contrary, the 'unrelated' controls outperformed the 'related' controls for the (untrained) bilabial consonants. Thus (as in Chapter 3), including the 'unrelated' control participants did not downgrade the performance of the Dutch control group.

Finally, the adoptees and Dutch controls showed more improvement in pronunciation of the trained alveolar than of the untrained bilabial and velar stops. This suggests that the improved pronunciation was indeed mainly induced by the perceptual training (Bradlow et al., 1999; Bradlow et al., 1997). The perceptual training in the present study, however, was not sufficient for the adoptees and Dutch controls to produce the target contrasts with a native-like accent. The evaluations for the productions from the Korean control participants were, as

expected, far better (i.e., productions were identified more accurately and rated more positively) than those for the adoptees and Dutch controls at the post-test.

Earlier studies have demonstrated similar benefits of early language exposure for speech production in non-adoptees (Au et al., 2002; Knightly et al., 2003; J. S. Oh et al., 2003). Similarly to the adoptees, the participants in those studies had regularly used a (heritage) language in their early years, and had thereafter experienced a considerable reduction in the amount of exposure to and use of the language. In contrast with the adoptees, however, they kept some contact with the heritage language, leaving open the possibility that the limited but continued exposure to the language affected the relearning advantages later in life. The present study thus supports and extends those previous findings, by showing that early linguistic experience can lead to relearning benefits in the domain of speech production, even when the cut-off from the childhood language was more thorough.

5 Perception of Japanese fricatives (Identification task)

5.1 Introduction

Previous studies have shown that phonological knowledge gained in early life can persist into adulthood when people keep receiving some (if only minimal) exposure to the language. This phonological knowledge provides an advantage at relearning phonemes of that language later in life (Bowers et al., 2009; J. S. Oh et al., 2003; Tees & Werker, 1984). The experiments in Chapters 3 and 4 of this dissertation provide evidence that this is also the case for adoptees, who have not been exposed to the birth language for many years, in line with tentative results from earlier studies addressing language memory in international adoptees (Hyltenstam et al., 2009; J. S. Oh et al., 2010).

The present study further explores the nature of the phonological memories of international adoptees. It is investigated whether the relearning benefit is limited to the exact phonemes that the adoptees have been exposed to in early life, or whether it can generalize to novel phonemes that are phonologically similar to some extent, but that are from a different language.

To that end, this study examined the same participants who took part in the studies described in Chapters 3 and 4, namely adult Korean adoptees in the Netherlands who were adopted by Dutch-speaking families in infancy and had been (entirely or almost entirely) disconnected from Korean since adoption, and the same group of Dutch control participants.

In Chapter 3, the Korean adoptees were found to outperform the Dutch control participants in learning to perceive Korean fortis, lenis, and aspirated stop consonants. In the present study, it is investigated if they also outperform the Dutch control participants in learning to perceive Japanese consonants that are phonologically partially similar to the Korean fortis and lenis consonants.

5.1.1 Japanese geminates, singletons, and long vowel targets

In the present study, all targets contained a form of the labiodental fricative (/f/). Although labiodental fricatives do not occur in the standard phoneme inventory of Japanese (Okada, 1999), they do occur as an allophone of the Japanese phoneme /h/ (Vance, 1987, pp. 19-20), and as marginal consonants, e.g. in loan words (see e.g. Kubozono, Itô, & Mester, 2008). Fricatives rather than stop consonants were chosen in order to keep the stimuli as different as possible from the Korean targets that the participants were also trained on in Chapter 3. Labiodental fricatives rather than alveolar or glottal fricatives were chosen in order to keep the stimuli as different as possible from Korean in general, which contains alveolar and glottal but not labiodental fricatives (Lee, 1999).

The Japanese target contrasts used were the geminate versus singleton affricates (/f:/ vs. /f/) in intervocalic position. Japanese distinguishes between geminate and singleton stops, affricates, and fricatives in intervocalic position (e.g., /kit:a/ "cut" vs. /kita/ "came") (Okada, 1999). In the present study, it is hypothesized that the Japanese geminates are perceptually to some extent comparable to the Korean fortis consonants in intervocalic position. Diachronically, geminate versus singleton contrasts are considered to be related to fortis versus lenis contrasts; i.e., they are seen as different diachronic forms of the same phenomenon (Idemaru & Guion, 2008, p. 169-170). Even more, Korean fortis stops are sometimes described as geminates (Choi, 1995; J. Han, 1996; M. Oh & Johnson, 1997), and

there is some overlap in the acoustic realization of Japanese geminates and Korean fortis stops, and of Japanese singletons and Korean lenis stops.

First, primary acoustic cues for the geminate-singleton contrast are durational: geminates are approximately twice as long as singletons, in terms of closure duration (for stops) and frication noise (for fricatives) (M. Han, 1992; Hardison & Saigo, 2010; Idemaru & Guion, 2008). Similarly, for Korean stops, in intervocalic position, closure duration is much longer for fortis than for lenis stops (Choi, 1995; J. Han, 1996; M. Oh & Johnson, 1997), and the difference in closure duration is a primary perceptual cue for native listeners of Korean (J. Han, 1996). Indeed, Korean listeners have been shown to use duration cues to distinguish between Japanese geminates and singletons (Minagawa & Kiritani, 1996).

Next, vowels show more creaky voicing after geminates than after singletons in Japanese (Idemaru & Guion, 2008). Similarly, in Korean, vowels show more creaky voicing after fortis than after lenis consonants (Cho et al., 2002).

Finally, pitch patterns are different after Japanese geminate and singleton consonants. For instance, for intervocalic stops, fundamental frequency (F0) falls more strongly from the preceding to the following vowel for geminates than for singletons (for stimuli that were all produced with a high-low pitch pattern; Idemaru & Guion, 2008)[10]. In Korean, similarly, pitch is related to the fortis versus lenis contrast; in word-initial position, pitch is higher after fortis stops than after lenis stops (Cho et al., 2002). The evidence about pitch in Japanese is rather limited and does not allow for a direct comparison with Korean; i.e., there are no studies investigating whether pitch is higher after geminates than after singletons, similar to the Korean pattern. It seems however that there might be some similarity in pitch patterns between the Japanese and Korean contrasts. In Korean, fortis consonants seem to lead to a

[10] Further, pitch patterns (high-low vs. low-high) affect whether consonants are interpreted as geminates or as singletons (Ofuka, 2003, written in Japanese and cited in Hardison & Saigo, 2010). Disyllabic words with a low-high pitch pattern require a longer closure duration in order to be interpreted as containing a geminate than those with a high-low pitch pattern.

stronger modulation of pitch than lenis stops (i.e., fortis stops are followed by high pitched vowels, whereas lenis stops seem to be followed by a modal pitch), similar to the pattern for Japanese intervocalic stops (Idemaru & Guion, 2008).

Thus, the durational cues, the voice quality, and possibly the pitch cues are similar for the geminate and fortis stops compared to the singleton and lenis stops.

Because of the phonological similarities between the Japanese and Korean consonants, the Japanese geminate-singleton contrast was expected to be relatively easy to distinguish for Korean listeners. Dutch, on the other hand, only distinguishes voiced and voiceless consonants, and does not have anything similar to fortis or geminate consonants (Gussenhoven, 1999). For Dutch listeners, indeed, Japanese geminate versus singleton consonants have been shown to be difficult to distinguish (Sadakata & McQueen, 2013).

A vowel length contrast was included to make the task more challenging (Hardison & Saigo, 2010; Sadakata & McQueen, 2013). Thus, a three-way Japanese length combination was formed. Whereas geminate fricatives were always preceded by a short vowel (Geminate condition), singleton fricatives were preceded by short vowels in one condition (Singleton condition) and by long vowels in another condition (Long Vowel condition). This resulted in triplets like, e.g., [af:e]-[afe]-[a:fe]. Vowel length is contrastive in Japanese and Dutch, but not in Korean. Thus, the Long Vowel condition might be relatively easy for the adoptees and Dutch controls. On the other hand, the duration of the preceding vowel is correlated with the geminate versus singleton status of the consonant, with longer vowels before geminates than singletons (Idemaru & Guion, 2008), which might hinder the recognition of long vowels; the adoptees and control participants might focus on the consonants and attribute vowel duration to the geminate-singleton contrast, which might make it more difficult for them to recognize long versus short vowels accurately.

In summary, Korean listeners were expected to benefit from the similarities between the Japanese and Korean consonant distinctions, making the Japanese three-way combination relatively easy to distinguish for Korean listeners. Note, however, that there are also clear differences between the distinctions in the two languages (e.g., in the acoustic realization, including the durational cues and voice quality, and particularly the exact pitch patterns associated with the distinctions), and that the distinction was here realized with the fricative /f/, which is not possible in Korean, so that the Japanese sounds might not be *very* easy to distinguish for the Korean listeners. For Dutch listeners, the Japanese three-way combination was expected to be difficult to distinguish. Indeed, the Japanese three-way length combination has been shown to be difficult to distinguish for native listeners of Dutch, although they improved significantly with training (Sadakata & McQueen, 2013). Crucially, the Korean adoptees might benefit from the similarity between the Korean and Japanese consonants when listening to the Japanese fricatives, due to their early exposure to Korean.

In the present study, the Korean adoptees and the Dutch control participants were trained in and tested on identifying the Japanese three-way length combination. Korean listeners participated in a single identification test. The results of the native Korean control participants were compared with those of the adoptees and Dutch control participants at the pre-test.

First, if Korean listeners benefit from the similarities between Japanese and Korean consonants, the Korean native listeners should outperform the Korean adoptees and Dutch controls. Second, and more importantly, if the Korean adoptees have persistent knowledge of Korean which helps them perceive novel phonemes that are phonologically to some extent similar to Korean phonemes, the adoptees should outperform the Dutch control participants in perceiving the Japanese three-way length combination.

5.2 Method

5.2.1 Participants

The same participants took part as described in the General Method (Chapter 2). The data from five of the Korean control participants were excluded because they had studied Japanese; there were 20 remaining native Korean control participants (10 female, 10 male, M_{age} = 29.2 years, range: 27-33 years).

5.2.2 Materials

A Japanese three-way length combination was used, consisting of (1) a long consonant preceded by a short vowel (henceforth Geminate), (2) a short consonant preceded by a short vowel (henceforth Singleton), and (3) a short consonant preceded by a long vowel (henceforth Long Vowel). The 25 minimal triplets that were recorded for the training by 10 speakers (see Chapter 2.3.2) were recorded for the test by a new speaker. The speaker was a 34 year-old female native speaker of Japanese (West dialect). Items were recorded and processed in a similar way as the training materials (Chapter 2).

5.2.3 Procedure

As described in the General Method, the adoptees and Dutch control participants took part in a pre-test (before the first training block), an intermediate test (after the 4th training block), and a post-test (after the 13th training block), whereas the Korean control participants participated in one test (with no training).

The further procedure was identical to that for the training (Chapter 2), except that participants did not receive feedback about the correctness for trials during the main test phase.

5.3 Results

First, the results of the native Korean control participants are compared to the pre-test results of the adoptees and the Dutch control participants. Second, and more importantly, it is investigated whether the Korean adoptees perform better than the Dutch control participants in perceiving the Japanese three-way length combination. Next, for the adoptees, the effect of age of adoption on their performance is assessed. Finally, for the Dutch control participants, it is investigated whether there is a difference between the Dutch control participants who are and those who are not related to Korean adoptees.

For all analyses, proportions of correct responses were used as dependent variable, and 31 responses with reaction times longer than 10,000 ms (0.2% of all responses) were considered as outliers and excluded from analysis.

5.3.1 Korean control participants versus adoptees and Dutch control participants

First, it was assessed whether, as predicted, Korean native listeners indeed benefited from the similarities between Korean and Japanese when listening to the Japanese three-way combination. The results of the native Korean control participants were compared with those of the adoptees and Dutch control participants at the pre-test.

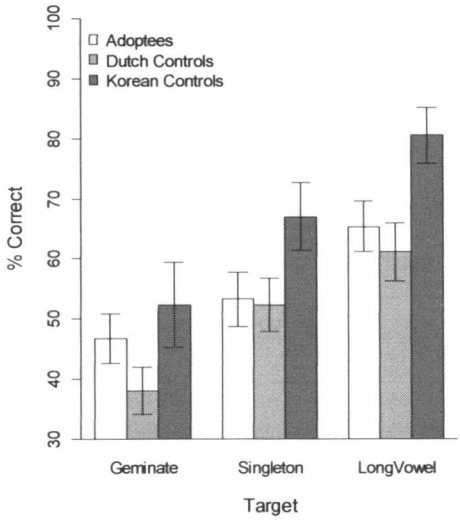

Figure 5.1. Percentage correct for Korean adoptees and Dutch controls at pre-test, and for Korean controls (who participated in a single test session), separately per target type. Error bars represent standard errors.

As Figure 5.1 shows, the native Korean controls outperformed the adoptees and the native Dutch controls on all targets, as they were expected to do. ANOVAs were carried out across participants (*F1*) and across items (*F2*) with the variables Group (adoptee, Dutch control, Korean control) and Target (Geminate, Singleton, Long Vowel). There was a significant main effect of Group, $F1(2, 75) = 4.247$, $p < .05$, $\eta_p^2 = .102$; $F2(2, 144) = 77.739$, $p < .05$, $\eta_p^2 = .519$. Follow-up analyses showed that the native Korean controls performed significantly better than the Dutch controls, $F1(1, 47) = 7.825$, $p < .05$, $\eta_p^2 = .143$; $F2(1, 72) = 148.456$, $p < .05$, $\eta_p^2 = .673$, while the difference between the Korean controls and the adoptees just missed significance in *F1*, $F1(1, 47) = 3.982$, $p = .052$, $\eta_p^2 = .078$; $F2(1, 72) = 64.175$, $p < .05$, $\eta_p^2 = .471$. There was no significant difference between the adoptees and the Dutch controls.

There was a significant main effect of Target as well, $F1(2, 150) = 32.182$, $p < .05$, $\eta_p^2 = .300$; $F2(2, 72) = 68.235$, $p < .05$, $\eta_p^2 = .655$. Participants performed worst for the Geminate targets and best for the Long Vowel targets (Geminate vs. Singleton: $F1(1, 75) = 21.988$, $p < .05$, $\eta_p^2 = .227$; $F2(1, 48) = 31.863$, $p < .05$, $\eta_p^2 = .399$; Geminate vs. Long Vowel: $F1(1, 75) = 66.153$, $p < .05$, $\eta_p^2 = .469$; $F2(1, 48) = 170.715$, $p < .05$, $\eta_p^2 = .781$; Singleton vs. Long Vowel: $F1(1, 75) = 12.287$, $p < .05$, $\eta_p^2 = .141$; $F2(1, 48) = 30.159$, $p < .05$, $\eta_p^2 = .386$).

In sum, the native Korean control participants performed better than both the adoptees and the Dutch control participants in identifying the Japanese three-way length contrast, presumably because of the similarity between Korean fortis and Japanese geminate consonants, and between Korean lenis and Japanese singleton consonants. Although the Korean native listeners outperformed the other two groups, their performance was far from being at ceiling. As discussed above, this could be partially due to the fact that Korean has no labiodental fricatives, and partially due to the differences in detailed phonetic realization of the Korean and Japanese contrasts.

The finding that the Korean listeners benefited from their native language experience in identifying the Japanese targets makes the Japanese three-way combination a useful test of the effect of early language experience in adoptees. In the next sections, Korean adoptees and Dutch control participants are compared.

5.3.2 Adoptees versus Dutch control participants

We explore whether the adoptees performed better than the Dutch control participants in identifying the Japanese three-way length combination at the pre-, intermediate, and post-tests.

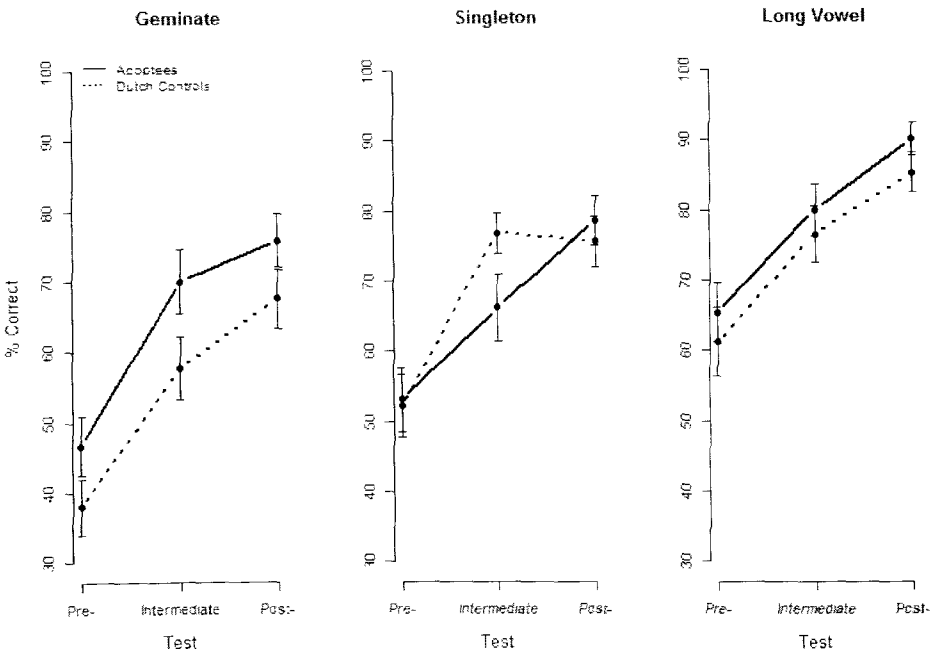

Figure 5.2. Percentage correct for the Geminate, Singleton, and Long Vowel targets, for Korean adoptees and Dutch controls, at pre-, intermediate, and post- tests. Error bars represent standard errors.

Importantly, as shown in Figure 5.2, the adoptees outperformed the Dutch controls on the Geminate targets throughout the three tests. ANOVAs were carried out across participants (*F1*) and across items (*F2*) with the variables Test (pre-test, intermediate test, post-test), Target (Geminate, Singleton, Long Vowel), and Group (adoptee, Dutch control). There was no effect of Group, but indeed there was a significant interaction between Target and Group, $F1(2, 112) = 5.201$, $p < .05$, $\eta_p^2 = .085$; $F2(2, 72) = 30.155$, $p < .05$, $\eta_p^2 = .456$. To further investigate that interaction, similar analyses with the variables Test (pre-test, intermediate test, post-test) and Group (adoptee, Dutch control) were conducted, separately for each target. For the Geminates, ANOVAs showed a significant effect of Group, $F1(1, 56) = 4.158$, $p < .05$, $\eta_p^2 = .069$; $F2(1, 24) = 62.792$, $p < .05$, $\eta_p^2 = .723$, with the adoptees outperforming the Dutch

controls. For the Singletons, there was no effect of Group. There was a significant interaction between Test and Group, $F1(2, 112) = 3.343$, $p < .05$, $\eta_p^2 = .056$; $F2(2, 48) = 17.018$, $p < .05$, $\eta_p^2 = .415$, but follow-up analyses showed no significant effects of Group at any of the tests. For the Long Vowels, there was no significant effect of Group, and there was no interaction between Test and Group.

Further, performance levels increased over time. The overall ANOVA showed a significant main effect of Test, $F1(2, 112) = 82.605$, $p < .05$, $\eta_p^2 = .596$; $F2(2, 144) = 339.521$, $p < .05$, $\eta_p^2 = .825$: Participants performed better at the intermediate test than at the pre-test, $F1(1, 56) = 60.884$, $p < .05$, $\eta_p^2 = .521$; $F2(1, 72) = 351.407$, $p < .05$, $\eta_p^2 = .830$, and better at the post-test than at the intermediate test, $F1(1, 56) = 21.388$, $p < .05$, $\eta_p^2 = .276$; $F2(1, 72) = 62.259$, $p < .05$, $\eta_p^2 = .464$. The proportion correct at the pre-test was above chance ($ps < .05$, assessed with one-sample t-tests), for Singleton and Long Vowel targets for both groups, and for Geminate targets for the adoptees but not for the Dutch controls.

Finally, the effect of Target was significant, $F1(2, 112) = 42.076$, $p < .05$, $\eta_p^2 = .429$; $F2(2, 72) = 24.594$, $p < .05$, $\eta_p^2 = .406$: Participants performed worst for the Geminate targets and best for the Long Vowel targets (Geminate vs. Singleton: $F1(1, 56) = 22.827$, $p < .05$, $\eta_p^2 = .290$; $F2(1, 48) = 8.048$, $p < .05$, $\eta_p^2 = .144$; Geminate vs. Long Vowel: $F1(1, 56) = 84.874$, $p < .05$, $\eta_p^2 = .602$, $F2(1, 48) = 81.510$, $p < .05$, $\eta_p^2 = .629$; Singleton vs. Long Vowel $F1(1, 56) = 19.891$, $p < .05$, $\eta_p^2 = .262$; $F2(1, 48) = 12.853$, $p < .05$, $\eta_p^2 = .211$).

In sum, whereas the adoptees and the Dutch controls performed equivalently for the Singleton and Long Vowel targets, the adoptees outperformed the Dutch controls on the identification of the Japanese Geminates, which were the most difficult of the target types used. It should be noted that the adoptees outperformed the Dutch controls already at the pre-test for the Japanese stimuli, whereas they outperformed the Dutch controls only at the intermediate test for the Korean stimuli in the experiment of Chapter 3. Possibly, this might

be because in all tests, the block testing the Japanese stimuli occurred after the three blocks testing the Korean stimuli, such that during the pre-test participants might have learned about the Korean contrasts and employed what they had learned to the Japanese stimuli. The adoptees might have been better than the Dutch controls at learning about the Korean contrasts and/or applying what they had learned to the Japanese stimuli. This could explain why the adoptees performed better than the Dutch controls for the Japanese stimuli already at the pre-test.

5.3.3 Age of Adoption

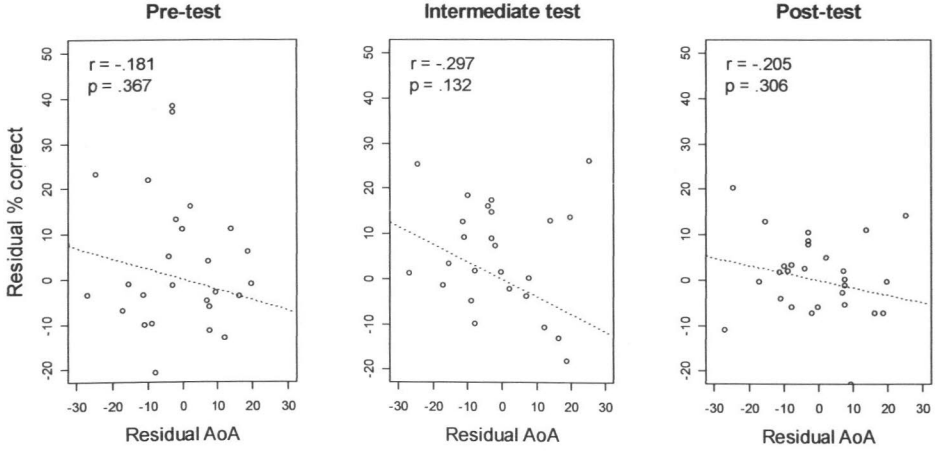

Figure 5.3. Partial regressions between Age of Adoption (AoA) and percentage correct for Japanese targets for adoptees on pre-, intermediate, and post-tests; the X-axis represents the residuals of the regression of the AoA on Age and Sex; the Y-axis represents the residuals of the regression of the percentage correct on Age and Sex; lines represent regression coefficients.

As in previous chapters (Chapters 3 and 4), the effect of Age of Adoption (AoA) was investigated in the adoptees' results. Partial correlations were calculated between AoA and the adoptees' performance at each of the three tests, while controlling for the effect of Age and Sex, as those variables were highly correlated with AoA (see Chapter 3.3.3, for more details).

Importantly, AoA was not significantly correlated with the adoptees' performance at the pre, intermediate or post-tests (see Figure 5.3; at pre-test: r = -.181, p = .367; at intermediate test: r = -.297, p = .132; at post-test: r = -.205, p = .306).[11] This shows that the length of exposure to Korean in early childhood did not determine the adoptees' performance on the Japanese contrast.

As in Chapter 3, the possible effect of AoA was further investigated with an ANCOVA, after grouping the adoptees in an early adopted group and a later adopted group (see Chapter 3.3.3 for details). The ANCOVA (carried out across participants) contained the variables Test (pre-test, intermediate test, post-test), Target (Geminate, Singleton, Long Vowel), and Binary AoA (early adopted, later adopted), and the covariates Age and Sex. There were no significant effects of binary AoA, or of any other variable, except that a main effect of the covariate Age was significant, $F(1, 25) = 5.672$, $p < .05$, $\eta_p^2 = .185$.[12] Thus, in line with the results of the correlational analysis, these results show again that AoA did not determine the adoptees' performance.[13]

The previous analyses have shown that AoA had little effect on performance. Therefore, it seems likely that the early adopted group should also outperform the Dutch control group. In order to investigate that, as in Chapter 3, the early adopted group was first compared to all Dutch control participants, and next to two different subgroups of the Dutch controls that were matched in size and on all control variables to the group of early adoptees

[11] Similar partial correlations, including Geminate targets only, also showed that AoA was not significantly correlated with adoptees' performance at any of the tests (at pre-test, r = -.082, p = .684; at intermediate test: r = -.182, p = .363; at post-test: r = -.047, p = .817).

[12] Again, a similar ANCOVA, including Geminate targets only, showed no significant effects of binary AoA, or of any other variable, except for a significant main effect of the covariate Age, $F(1, 25) = 7.274$, $p < .05$, $\eta_p^2 = .225$.

[13] Note that the effect of Length of Residence in the Netherlands (LoRN) could not be investigated, for the same reason as in Chapter 3. LoRN had a very strong positive correlation with Age, r = .951, $p < .05$, which was negatively correlated with the adoptees' performance at the three tests (pre-test: r = -0.341, p = .07, intermediate test: r = -0.550, $p < .05$, post-test: r = -0.699, $p < .05$). Similarly, in an analysis including Geminate targets only, Age was again negatively correlated with the adoptees' performance at the three tests (pre-test: r = -0.249, p = .193; intermediate test: r = -0.478, $p < .05$; post-test: r = -0.668, $p < .05$).

(see Chapter 3.3.3 for details). Importantly, there was a significant main effect of Group in all three analyses, with the early adopted group outperforming the Dutch control groups (with all control participants: $F(1, 40) = 6.935$, $p < .05$, $\eta_p^2 = .148$; with the first control subgroup: $F1(1, 26) = 4.289$, $p < .05$, $\eta_p^2 = .142$; $F2(1, 72) = 123.593$, $p < .05$, $\eta_p^2 = .632$; with the second control subgroup: $F1(1, 26) = 4.458$, $p < .05$, $\eta_p^2 = .146$; $F2(1, 72) = 86.05$, $p < .05$, $\eta_p^2 = .544$.).

In line with the correlational analysis, these findings confirm that even less than six months of exposure to Korean in infancy has conferred on the adoptees an advantage at perceiving the novel Japanese phonemes. That is, a very few months of early exposure are sufficient to produce phonological knowledge of the birth language which many years later is still generalizable to a new phoneme contrast, of a different language, that has some phonological similarity to a contrast of the birth language.

5.3.4 Homogeneity of Dutch control participants

Half of the Dutch control participants were related to Korean adoptees (i.e., sibling or partner of a Korean adoptee). As in Chapter 3, it was assessed whether the presence of such a relationship affected the Dutch control participants' performance, with an ANOVA (across participants) including the variables Test (pre-test, intermediate test, post-test), Target (Geminate, Singleton, Long Vowel), and Relationship to adoptees (related, unrelated). Consistent with Chapter 3, there were no significant effects of Relationship to adoptees, again confirming the validity of the control group.

5.4 Discussion

The present study shows that the relearning benefit for adoptees that was found for phonemes of the birth language (Chapters 3 and 4) is not limited to the exact phonemes that the

adoptees have been exposed to in early childhood, but rather that their knowledge of the birth language can be generalized to new, partially overlapping, phoneme contrasts of a different language. Korean adoptees in the Netherlands and Dutch control participants were trained in and tested on identifying the Japanese geminate versus singleton contrast, which is phonologically partially similar to the Korean fortis versus lenis consonant distinction (see Chapter 5.1.1). First, the results showed that native Korean listeners indeed performed better than the adoptees and Dutch controls in identification of the Japanese targets. This confirms that the Japanese contrast is a proper target contrast to assess the effect of the adoptees' early experience with Korean. Next, and importantly, it was shown that the adoptees outperformed the control participants in identifying the Japanese Geminates.

Note that the difference between the adoptees and the Dutch controls is likely to be the result of the adoptees' generalization of their knowledge of Korean consonants, and not of any prior exposure to Japanese. Although Korea and Japan are neighbouring countries, it is highly unlikely that the adoptees have been exposed to Japanese in Korea before adoption. Due to the political relations between Korea and Japan, and the cultural policy of the Korean government in the 1970s and 1980s, when the adoptees who took part in this study were in Korea, Japanese was not commonly heard in Korea in that era, and there was no access to products of Japanese culture (such as movies, cartoons, theatrical performances, television shows, or music). This did not change until the late 1990s, when the warming of political relations between the countries led to more access to Japanese language and culture in Korea.

Whereas the adoptees outperformed the Dutch controls on the Geminate targets, both groups performed equivalently on the Singleton and Long Vowel targets. Knowledge of Korean might have aided the recognition of Geminates, but not of Singletons and Long Vowels for the adoptees: Geminates are very different from any Dutch phonemes, which might have left room for the adoptees to benefit from experience with Korean. (Indeed,

performance on Geminate targets was worse than on Singleton and Long Vowel targets.) Singleton consonants, on the other hand, either following a short vowel or a long vowel, can be found in Dutch too, which might have obliterated any influence of experience with Korean. Note that, as Korean has no vowel length contrast, the adoptees were not expected to be better than the Dutch controls at perceiving the difference between the Singleton and Long Vowel targets. Together, these explanations account for the adoptees' and controls' equivalent performance for the Singleton and Long Vowel targets.

For the adoptees, it was investigated whether a longer period of exposure to Korean before adoption led to a better performance in the present study. Surprisingly, but similar to the findings of the experiments in Chapters 3 and 4, the results consistently showed that the duration of early exposure to Korean did not affect the adoptees' performance on the Japanese consonant length contrast. First, age of adoption (three to 70 months old) was not significantly correlated with the adoptees' performance in the pre-, intermediate, and post-tests. Second, a subgroup comprising the early adoptees, who were adopted before five months of age, performed as well as the subgroup comprising the later adoptees, who were adopted after 17 months of age. Finally, the subgroup of the early adoptees outperformed the Dutch control participants (represented either by all control participants or by two different subgroups of control participants). Taken together, these findings indicate that, after several decades of not using the birth language, the amount of early exposure to the language does not affect the relearning benefit in adulthood. Importantly, the findings also show that even a few months of experience with the birth language in infancy are sufficient to leave a long-lasting knowledge of the phonology of the birth-language, which can be generalized and applied during the acquisition of novel phonemes.

For the Dutch controls, the presence or absence of a connection to Korean adoptees did not affect the controls' performance. There was no difference between those Dutch

controls who were related to Korean adoptees (i.e., siblings or partners of Korean adoptees) and those who were not related to Korean adoptees. This confirms the finding from the previous chapters that our control group, including the 'unrelated' controls, can be considered as suitable as a control group consisting entirely of 'related' control participants.

Finally, this study raises the interesting question whether the adoptees might be better than control participants at learning *any* novel phoneme contrast, regardless of its phonological similarity to the sounds of their birth language. The Japanese contrast here was carefully selected to overlap with Korean sounds, and we assume that the adoptees' experience with Korean has aided them in learning the Japanese sounds. Nevertheless, it is possible that international adoptees are good language learners in general, due to their unusual experience of successively acquiring two first languages during the sensitive period for language learning (Lenneberg, 1967). This unique learning experience might give adoptees an advantage in phoneme learning. Further research is needed to investigate this possibility.

6 Perception of Korean and Japanese consonants (Discrimination task)

6.1 Introduction

In previous chapters, it has been demonstrated that phonological knowledge that international adoptees obtained in early childhood can be preserved without continuous usage and can facilitate the relearning of birth language sounds. The experiment in Chapter 3 showed that the Korean adoptees outperformed the Dutch controls on identification of the Korean contrasts at the trained place of articulation, and on generalizing what they had learned to the untrained places of articulation. In the experiment of Chapter 5, the adoptees were better than the Dutch control participants at identification of the Japanese geminate-singleton contrast that was to some extent similar to the Korean fortis-lenis contrast.

The adoptees' (re)learning benefits were measured by identification tasks. This suggests that the benefits might reflect more accurate *categorization* of the target sounds. Adoptees might have formed more accurate mental representations of the target phonetic categories, and/or might have been better at assigning the target sounds to the appropriate phonetic categories than the Dutch controls. The present study further explores the nature of the (re)learning benefits found in earlier chapters, by investigating whether the adoptees also outperform the Dutch controls when a discrimination task is used.

It has been proposed that Identification and Discrimination tasks tap into different perception processes (Broersma et al., 2013; Gerrits & Schouten, 2004; Sadakata &

McQueen, 2013). Although it is so far not clear what exactly the two tasks measure, several studies have shown that they sometimes yield very different outcomes, which suggests that the two tasks tap into different perception processes (Broersma et al., 2013; Gerrits & Schouten, 2004; Sadakata & McQueen, 2013). For instance, listeners can successfully assign sounds to different phonetic categories in an identification task, and yet fail to discriminate the sounds in a discrimination task (Gerrits & Schouten, 2004). Also, a relatively weak correlation between Identification and Discrimination has been reported (Broersma et al., 2013).

In the present study, we examine the same participants and the same Korean and Japanese target sounds, now using discrimination tasks. Without any training on discrimination, the participants were tested on discrimination of the Korean contrasts (Experiment 1), and of the Japanese contrast (Experiment 2). The question investigated here is thus whether the adoptees also outperform the Dutch controls in the perception of the Korean and Japanese sounds when a discrimination task is used.

6.2 Experiment 1: Korean consonants

As in Chapter 3, the target contrast is the Korean fortis-lenis-aspirated stop consonant contrast. The contrast is difficult to distinguish for native listeners of Dutch, as was confirmed in Chapter 3. The primary research question is whether the Korean adoptees are better than the Dutch control participants at discriminating the Korean stop categories, as they were at identifying the phonemes in Chapter 3. A secondary question is whether the adoptees and the Dutch controls approached Korean native-like performance after extensive training. This is assessed by comparing the results of the adoptees and Dutch controls to those of the native Korean control participants (who took part in a single test). Finally, it is assessed

whether certain combinations of fortis, lenis, and aspirated targets are more difficult to distinguish than others, for all three participant groups.

6.2.1 Method

6.2.1.1 Participants

As described in the General Method, the 29 adoptees and 29 Dutch control participants participated in a pre-test (before the first training block), an intermediate test (after the 4th training block), and a post-test (after the 13th training block), and the 25 Korean control participants took part in one test (with no training).

6.2.1.2 Materials

The crucial contrast was again the Korean three-way stop contrast, of fortis, lenis, and aspirated stops. During the tests, discrimination of the fortis, lenis, and aspirated stops was tested at three places of articulation: alveolar [t*, t, t^h], bilabial [p*, p, p^h], and velar [k*, k, k^h]. As described in the General Method, during the training, participants were only trained to identify the three-way contrast at the alveolar place of articulation.

There were three sets of stimuli; the first for alveolar stops, the second for bilabial stops, and the third for velar stops. All sets contrasted fortis, lenis, and aspirated manner of articulation.

For each of the three sets, three minimal triplets of consonant-vowel-consonant-vowel (CVCV) Korean pseudowords were created (Table 6.1). Within each triplet, items varied only in word-initial fortis, lenis, and aspirated stops. The initial syllables consisted of the crucial stops followed by the vowels [a], [i], or [u]. The final syllables were always [mi].

Table 6.1. Experiment 1: minimal triplets

Place of articulation	Fortis	Lenis	Aspirated
Alveolar	[t*ami]	[tami]	[t^hami]
	[t*ɯmi]	[tɯmi]	[t^hɯmi]
	[t*umi]	[tumi]	[t^humi]
Bilabial	[p*ami]	[pami]	[p^hami]
	[p*imi]	[pimi]	[p^himi]
	[p*umi]	[pumi]	[p^humi]
Velar	[k*ami]	[kami]	[k^hami]
	[k*imi]	[kimi]	[k^himi]
	[k*umi]	[kumi]	[k^humi]

The same native speaker of Korean who recorded the materials for the Identification test in Chapter 3 recorded multiple tokens of all 27 items (i.e., nine triplets). Four tokens of each item were selected for the test (with a total of 108 tokens). Stimuli were recorded and excised as described in the General Method.

In each set, 36 tokens were used four times to form 72 pairs: 36 pairs in the Same condition, and 36 pairs in the Different condition. Of the pairs in the Different condition, 18 were experimental pairs that differed in the crucial stop contrast; the other 18 pairs were filler pairs that differed in the vowels in the first syllable. For the 18 Different *experimental* pairs, each consonant type was paired with every other consonant type (i.e., fortis-lenis, fortis-aspirated, lenis-aspirated) in both orders three times. For the 18 Different *filler* pairs, similarly, each first vowel was paired with every other first vowel (i.e., [a]-[i], [a]-[u], [i]-[u]) in both orders three times. The pairs in the Same condition always consisted of two different tokens of the same item, i.e., the same token was never repeated within a pair. All items and tokens occurred in the first and second position of a pair an equal number of times.

6.2.1.3 Procedure

Each of the pre-, intermediate, and post-tests consisted of three blocks. Those three blocks tested the contrasts at alveolar, bilabial and velar place of articulation, respectively, in that order for all participants. A discrimination task was used. Each block started with a written instruction, followed by eight practice trials, a break during which participants could ask questions, and the main test phase.

Participants were informed that they would hear two words. They were asked to determine whether the two words were the same or different. Each trial started with a fixation mark on the computer screen for 400 ms, followed by a 400 ms delay, auditory presentation of the first stimulus, an interstimulus interval (ISI) of 500 ms. and auditory presentation of the second stimulus. Participants pressed one of two keys on the computer keyboard to give their response: "H" (for "Hetzelfde" meaning *the same* in Dutch) if they thought that the two words were the same, or "A" (for "Anders" meaning *different*) if they thought that the two words were different. There was no time-out for responses. For all participants, in each test session, all 72 pairs were presented, in a random order.

The eight practice trials were identical to the test trials except that feedback was given after each practice trial. The practice trials contained stimuli that were used during the test, but that were paired differently. Feedback was given in the same way as during the training (see General Method).

6.2.2 Results

First, using the results from all experimental pairs (i.e., for the Same pairs and the Different experimental pairs together), the Korean adoptees' performance is compared with that of the Dutch control participants. It is examined whether the adoptees performed better than the Dutch control participants, whether participants' performance improved over time, and

whether participants improved more on the trained alveolar contrast than on the similar but untrained bilabial and velar contrasts. Second, using the results from the Different experimental pairs only, we explore whether there are differences among fortis-lenis, fortis-aspirated, and lenis-aspirated stop comparisons. Finally, the results of the native Korean control participants are compared to the post-test results of the adoptees and the Dutch control participants.

6.2.2.1 Overall sensitivity

Table 6.2 shows the adoptees' and Dutch controls' overall percentage of correct responses for all experimental pairs (i.e., for the Same pairs and the Different experimental pairs together). As the table shows, the adoptees and controls performed very alike at all tests.

Table 6.2. Experiment 1: percentage correct for all experimental pairs across all three places of articulation (and standard error), separately for Korean adoptees and Dutch controls at pre-, intermediate, and post-tests, and for Korean controls at a single test.

Test	Adoptees	Dutch Controls	Korean Controls
Pre-	78.11 (1.38)	78.65 (1.05)	95.68 (0.41)
Intermediate	80.66 (1.56)	80.78 (1.21)	-
Post-	79.83 (1.52)	79.72 (1.31)	-

As a measure of perceptual sensitivity, *d'* (d-prime) values were used as dependent variable (McNicol, 1972). *d'* was calculated for each participant, test, and place of articulation separately, using the Same and Different experimental pairs (see Table 6.3). When 'Hits' or 'False alarms' were either 0.00 or 1.00, those values were substituted by 0.01 and 0.99, respectively (Macmillan & Creelman, 1991). Responses with reaction times (RTs) longer than 5,000 ms (293, 1.0 % of all responses) were considered as outliers and excluded from analysis.

First, the adoptees and Dutch controls are compared. An ANOVA on *d'* was carried out across participants with the variables Test (pre-test, intermediate test, post-test), Place of articulation (alveolar, bilabial, velar), and Group (adoptee, Dutch control). Indeed, as Table 6.2 already suggests, there was no significant main effect of Group and no significant interaction between Group and Test. There was a significant interaction between Group and Place of articulation, $F(2, 112) = 4.904$, $p < .05$, $\eta_p^2 = .081$, but follow-up analyses showed that there was no difference between the groups for any of the alveolar, bilabial, or velar places of articulation. In short, there were no significant differences between the adoptees and the Dutch controls.

Table 6.3. Experiment 1: *d'* (and standard error) for alveolar, bilabial, and velar targets, separately for Korean adoptees and Dutch controls at pre-, intermediate, and post-tests, and for Korean controls at a single test. (Higher values of *d'* indicate greater sensitivity.)

	Pre-test		Intermediate test		Post-test		
Place of Articulation	Adoptees	Dutch Controls	Adoptees	Dutch Controls	Adoptees	Dutch Controls	Korean Controls
Alveolar	1.45 (0.09)	1.61 (0.11)	1.70 (0.10)	2.06 (0.13)	1.74 (0.12)	1.80 (0.10)	3.59 (0.07)
Bilabial	1.44 (0.08)	1.57 (0.06)	1.63 (0.10)	1.48 (0.06)	1.47 (0.07)	1.50 (0.11)	3.94 (0.06)
Velar	1.89 (0.12)	1.57 (0.11)	1.99 (0.15)	1.88 (0.11)	2.02 (0.16)	1.86 (0.09)	3.39 (0.09)
Overall	1.54 (0.11)	1.54 (0.09)	1.73 (0.13)	1.73 (0.10)	1.68 (0.13)	1.67 (0.12)	3.55 (0.10)

Second, it was assessed whether participants improved over time. The same ANOVA as described above showed that there was a significant main effect of Test, $F(2, 112) = 6.772$, $p < .05$, $\eta_p^2 = .108$. Participants' sensitivity was better at the intermediate test than at the pre-test, $F(1, 56) = 10.461$, $p < .05$, $\eta_p^2 = .157$, but there was no difference between the intermediate and the post-test (see Table 6.3). Thus, participants improved, but only in the earlier stages of the training and testing period.

Finally, it was assessed whether participants improved more on the trained (alveolar) than on the untrained (bilabial and velar) places of articulation (see Table 6.3). That was not the case; there was no interaction between Test and Place of articulation, showing that improvement did not significantly differ for the three places or articulation. There was, however, a significant main effect of Place of articulation, $F(2, 112) = 16.089$, $p < .05$, $\eta_p^2 = .223$. Follow-up analyses showed that participants' perceptual sensitivity was the best for the velars, intermediate for the alveolars, and the worst for the bilabials (velar vs. alveolar: $F(1, 56) = 5.104$, $p < .05$, $\eta_p^2 = .084$; alveolar vs. bilabial: $F(1, 56) = 16.182$, $p < .05$, $\eta_p^2 = .224$; velar vs. bilabial: $F(1, 56) = 24.344$, $p < .05$, $\eta_p^2 = .303$).[14] In short, participants did not improve more on the trained than on the untrained places of articulation, and there was an overall effect of place of articulation which was similar for both groups.

6.2.2.2 Comparison types

To investigate how the participants perceived the differences between fortis-lenis, fortis-aspirated, and lenis-aspirated stop comparisons, additional analyses were done with the Different experimental pairs only. Note that the Same pairs are not informative to this end. Because only Different experimental trials are used, no *d'* could be calculated (as *d'* requires both Same and Different trials). Therefore, proportions of correct responses for the Different experimental pairs were used as the dependent variable. Again, responses with RTs longer than 5,000 ms (105, 1.0 % of all responses) were excluded from analysis.

[14] Because there was a significant interaction between Group and Place of articulation, the effect of place of articulation was also assessed for both groups separately. The adoptees showed a pattern similar to the overall pattern (i.e., velars > alveolars > bilabials), but some of the comparisons did not reach significance [velars > (alveolars = bilabials)] (velars vs. alveolars $F(1, 28) = 11.627$, $p < .05$, $\eta_p^2 = .293$; velars vs. bilabials: $F(1, 28) = 21.278$, $p < .05$, $\eta_p^2 = .432$). The Dutch controls showed a pattern partially similar to the overall pattern (Table 6.2), but, again, some of the comparisons did not reach significance [(alveolars = velars) > bilabials] (alveolars vs. bilabials: $F(1, 28) = 12.634$, $p < .05$, $\eta_p^2 = .311$; velars vs. bilabials, $F(1, 28) = 5.876$, $p < .05$, $\eta_p^2 = .173$).

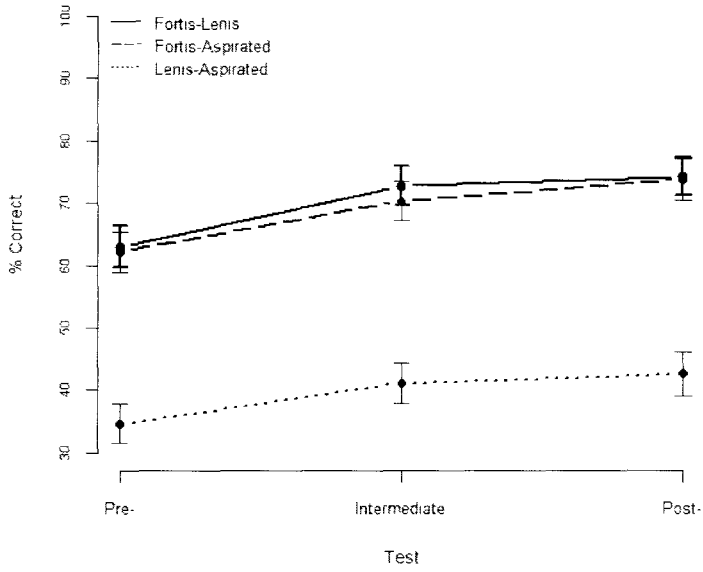

Figure 6.1. Experiment 1: percentage correct for three comparison types for Korean adoptees and Dutch controls, at pre-, intermediate, and post-tests (collapsed over place of articulation). Error bars represent standard errors.

As Figure 6.1 and Table 6.4 show, for both groups alike, the lenis-aspirated pairs received a much lower percentage correct than the fortis-lenis and the fortis-aspirated pairs, while there was no difference between the fortis-lenis and fortis-aspirated pairs. ANOVAs were carried out across participants (*F1*) and across items (*F2*) with the variables Test (pre-test, intermediate test, post-test), Place of articulation (alveolar, bilabial, velar), Comparison type (fortis-lenis, fortis-aspirated, lenis-aspirated), and Group (adoptee, Dutch control). Indeed, there was a significant main effect of Comparison type, $F1(2, 112) = 71.466$, $p < .05$, $\eta_p^2 = .561$; $F2(2, 45) = 31.560$, $p < .05$, $\eta_p^2 = .584$. Follow-up analyses confirmed that the lenis-aspirated comparisons received significantly fewer correct responses than the other two comparison types (fortis-lenis vs. lenis-aspirated: $F1(1, 56) = 118.589$, $p < .05$, $\eta_p^2 = .679$;

$F2(1, 30) = 44.797$, $p < .05$, $\eta_p^2 = .599$; fortis-aspirated vs. lenis-aspirated: $F1(1, 56) = 60.294$, $p < .05$, $\eta_p^2 = .518$; $F2(1, 30) = 50.685$, $p < .05$, $\eta_p^2 = .628$.), while there was no difference between the fortis-lenis and the fortis-aspirated comparisons. (We will come back to these results in the following section, Chapter 6.2.2.3.)

In line with the *d'* analysis that was performed on the full data set, there was no significant main effect of Group and no significant interaction between Group and Test, or between Group and Comparison type. All other effects on this subset of the data were also largely in line with the *d'* analysis performed on the full data set.[15]

In short, these analyses show that fortis consonants are easier to distinguish from the lenis and aspirated consonants than the other two from each other both for adoptees and Dutch controls.

Table 6.4. Experiment 1: percentage correct (and standard error) for Fortis-Lenis, Fortis-Aspirated and Lenis-Aspirated comparisons across all three places of articulation, separately for Korean adoptees and Dutch controls at pre-, intermediate, and post-tests, and for Korean controls at a single test.

Pairing	Pre-test		Intermediate test		Post-test		
	Adoptees	Dutch Controls	Adoptees	Dutch Controls	Adoptees	Dutch Controls	Korean Controls
Fortis-Lenis	61.0 (4.7)	65.0 (4.8)	70.9 (4.5)	74.6 (4.3)	76.4 (4.2)	72.1 (4.6)	99.6 (0.3)
Fortis-Aspirated	59.9 (4.5)	64.5 (4.8)	67.3 (4.6)	73.3 (4.1)	75.0 (4.7)	72.6 (4.9)	99.6 (0.3)
Lenis-Aspirated	29.3 (4.1)	40.0 (4.7)	37.5 (4.2)	44.7 (4.8)	39.7 (5.4)	45.6 (4.7)	80.4 (3.2)
Overall	50.0 (3.1)	56.5 (4.0)	58.6 (3.7)	64.3 (3.7)	63.6 (3.9)	63.4 (3.9)	93.1 (1.5)

[15] In contrast to the *d'* analysis, there was no significant main effect of Place of articulation either overall or for the adoptees and for the controls separately. Also in contrast to the *d'* analysis, there now was a significant interaction between Test and Place of articulation ($ps < .05$).

6.2.2.3 Korean control participants

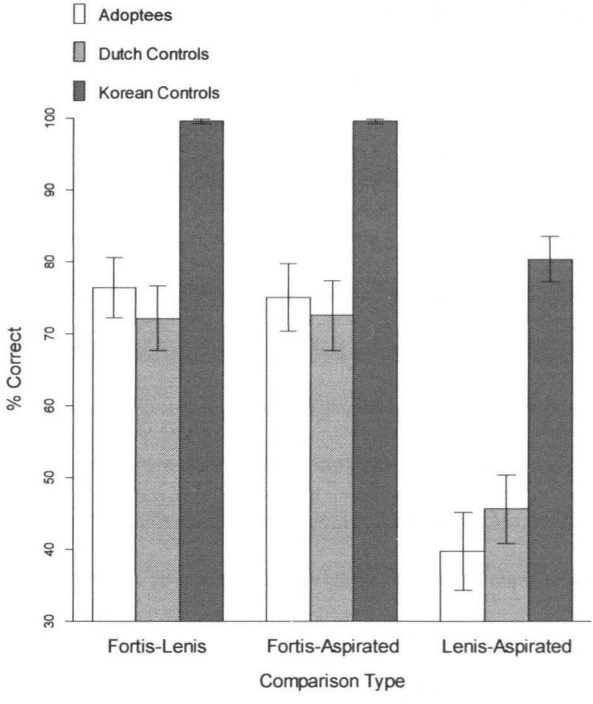

Figure 6.2. Experiment 1: percentage correct for Fortis-Lenis, Fortis-Aspirated and Lenis-Aspirated comparisons (collapsed over place of articulation), separately for Korean adoptees and Dutch controls at the post-test, and for Korean controls. Error bars represent standard errors.

It was assessed to what extent the performance of the adoptees and Dutch controls differed from that of the Korean controls. Korean controls participated in a single test session, and they were expected to perform much better than the adoptees and Dutch controls. Indeed, as Figure 6.2 clearly shows, Korean controls had a very high accuracy, and strongly outperformed the adoptees and Dutch controls. (While Figure 6.2 shows the results of the Different experimental trials only, a similar outcome is found when the Same and Different experimental trials are analysed together; see Table 6.2.)

In the following statistical analyses, the results of the Korean control participants are compared to those of the adoptees and Dutch controls at the post-test (rather than the pre- or

intermediate test), in order to assess to what extent the adoptees and the Dutch control participants approached Korean native-like performance after the extensive training. Analyses were done, first, with d' as the dependent variable, and then with proportions of correct responses for the Different experimental pairs.

First, an ANOVA with d' as the dependent variable was carried out across participants with Place of articulation (alveolar, bilabial, velar) and Group (adoptee, Dutch control, Korean control) as independent variables. As expected, there was a significant main effect of Group, $F(2, 80) = 84.158$, $p < .05$, $\eta_p^2 = .678$. Further, there was a significant interaction between Place of articulation and Group, $F(4, 160) = 10.240$, $p < .05$, $\eta_p^2 = .204$. Following up on that interaction, the Korean controls were compared with, first, the adoptees and second, the Dutch controls, at each place of articulation; six t-tests were carried out (3 places of articulation * 2 groups) on d' values, across participants, using Bonferroni correction. All the comparisons showed significant effects (Bonferroni corrected ps $< .001$). Thus, the native Korean participants performed significantly better than the adoptees and the Dutch controls in all three places of articulation.[16]

Next, analyses were undertaken with proportions of correct responses for the Different experimental pairs only (as in Chapter 6.2.2.2). In ANOVAs with Place of articulation (alveolar, bilabial, velar), Comparison type (fortis-lenis, fortis-aspirated, lenis-aspirated), and Group (adoptee, Dutch control, Korean control), there were significant main effects of Group, $F1(2, 80) = 24.266$, $p < .05$, $\eta_p^2 = .378$; $F2(2, 90) = 191.718$, $p < .05$, $\eta_p^2 = .810$ and Comparison type, $F1(2, 160) = 81.899$, $p < .05$, $\eta_p^2 = .506$; $F2(2, 45) = 50.034$, $p < .05$, $\eta_p^2 = .690$, and a significant three-way interaction between Place of articulation,

[16] To assess the effect of place of articulation for the Korean native listeners, three t-tests were done in a similar way. The results showed that the Korean controls' perceptual sensitivity was better for the bilabials than for the alveolars and velars, whereas there was no difference between the alveolars and the velars (see Table 6.3) (alveolar vs. bilabial: $t(24) = -2.102$, $p < .05$; velar vs. bilabial: $t(24) = 3.736$, $p < .05$). Thus, their pattern of results [i.e., bilabials > (alveolars = velars)] was different from the pattern for the adoptees and Dutch controls.

Comparison type, and Group, $F1(8, 320) = 3.871$, $p < .05$, $\eta_p^2 = .088$; $F2(8, 90) = 2.074$, $p < .05$, $\eta_p^2 = .156$. Following up on the three-way interaction, the Korean controls were compared, first, with the adoptees and second, with the Dutch controls, at each place of articulation; 18 *t*-tests were carried out (3 places of articulation * 3 comparison types * 2 groups) across participants and across items, using Bonferroni correction. In line with the *d'* analysis, all the comparisons showed significant effects (Bonferroni corrected *p*s < .05), except for two analyses that missed significance in the by-item analysis[17], confirming that the native Korean participants performed better than the adoptees and the Dutch controls in all the comparisons. Finally (and again following up on the three-way interaction), to assess the effect of comparison type for the Korean native listeners, ANOVAs were carried out across participants (*F1*) and across items (*F2*) for the Korean controls only, with the variables Place of articulation (alveolar, bilabial, velar), and Comparison type (fortis-lenis, fortis-aspirated, lenis-aspirated). There was a significant main effect of Comparison type, $F1(2, 48) = 38.787$, $p < .05$, $\eta_p^2 = .618$; $F2(2, 45) = 38.541$, $p < .05$, $\eta_p^2 = .631$. Follow-up analyses showed that the effect of comparison type was similar to the effect for the adoptees and Dutch controls: the lenis-aspirated comparisons received significantly fewer correct responses than the other two comparison types (fortis-lenis vs. lenis-aspirated: $F1(1, 24) = 38.703$, $p < .05$, $\eta_p^2 = .617$; $F2(1, 30) = 38.979$, $p < .05$, $\eta_p^2 = .565$; fortis–aspirated vs. lenis-aspirated: $F1(1, 24) = 39.733$, $p < .05$, $\eta_p^2 = .623$; $F2(1, 30) = 38.924$, $p < .05$, $\eta_p^2 = .565$.), while there was no difference between the fortis-lenis and the fortis-aspirated comparisons (again for all three places of articulation). Thus, for the Korean controls, lenis-aspirated was more difficult than the other two comparison types, similar to the adoptees and Dutch controls. This suggests that

[17] The by-items analyses missed significance for the /t/-/tʰ/ comparison with the Dutch controls, and for the /p/-/p*/ comparison with the adoptees

the difficulty of the lenis-aspirated combination for all groups was the result of intrinsic difficulty of the contrast (rather than e.g. interference from the Dutch phonological system).

The results of the analyses presented in this section show that the Korean control participants outperformed the adoptees and Dutch control participants at all places of articulation and for all comparison types. Thus, as expected, the training was not enough for the adoptees and the Dutch control participants to achieve native-like performance in discriminating Korean stop consonants. Further, the Korean controls showed a similar pattern of results for the three comparison types as the adoptees and Dutch controls, with lenis-aspirated being the most difficult comparison.

Thus, the Korean fortis stops were more easily distinguishable from lenis and aspirated stops than the latter two from each other, for all three groups alike. This finding is in line with Chapter 3, where the proportion correct was higher for fortis than for lenis or aspirated stops, as well as with previous research (Broersma, 2009). For the adoptees and Dutch controls, this could be explained by the differences between Korean and Dutch phonology. Fortis stops could be expected to be easiest to distinguish for Dutch listeners because they are most similar to Dutch stops (namely voiceless stops) in terms of Voice Onset Time (VOT): Fortis stops are unaspirated, lenis stops slightly aspirated, and aspirated stops are strongly aspirated. Accordingly, VOTs are shortest in fortis stops (approximately 20 ms on average), medium in lenis stops (70 ms), and longest in aspirated stops (120 ms) (Cho et al., 2002). As the Korean fortis stops, Dutch voiceless stops are unaspirated, with VOTs of about 25 ms (van Alphen & Smits, 2004). (In addition, Dutch has voiced stops which are produced with prevoicing (van Alphen & Smits, 2004).) Given the fact that fortis stops are most similar to Dutch stops, the Perceptual Assimilation Model (Best, 1994; Best & Tyler, 2007) would predict the fortis stops to be the easiest to discriminate for native listeners of Dutch. However, another possible explanation (and, given the results of the Korean controls,

a more likely one) could be that the lenis-aspirated contrast is intrinsically more difficult than the other two contrasts. All participants had difficulty discriminating the lenis from the aspirated stops. The adoptees and Dutch controls scored below chance level (i.e., 50%) even at the post-test, and the Korean control participants had only 80.4% correct for the lenis-aspirated pairs, whereas their performance was almost flawless for the fortis-lenis (99.6%) and the fortis-aspirated comparisons (99.6%). This suggests that the acoustic cues distinguishing between lenis and aspirated stops are relatively weak, making it a relatively difficult distinction even for native listeners of Korean.

6.3 Experiment 2: Japanese consonants

In the present experiment, the same Japanese three-way length combination is used as in Chapter 5. The experiment reported in Chapter 5 has shown that the adoptees outperformed the Dutch control participants in identifying Japanese geminate consonants. The present study investigates whether the adoptees also outperform the Dutch controls in discriminating the same combination. Further, we examine whether native listeners of Korean outperform the adoptees and Dutch controls in discriminating the Japanese combination, as they did in the identification task of Chapter 5.

6.3.1 Method

6.3.1.1 Participants

The same participants who took part in Experiment 1 participated in the present study. Five Korean control participants were excluded from analysis because they had previously studied Japanese, leaving 20 Korean control participants (10 female, 10 male, M_{age} = 29.2 years, range: 27-33 years).

6.3.1.2 Materials

The crucial contrast was the Japanese three-way length combination, consisting of (1) a long consonant preceded by a short vowel (henceforth Geminate), (2) a short consonant preceded by a short vowel (henceforth Singleton), and (3) a short consonant preceded by a long vowel (henceforth Long Vowel) (see Chapter 5).

Three minimal triplets of vowel-consonant-vowel (VCV) Japanese pseudowords were created (Table 6.5). The triplets contrasted the Geminate, Singleton, and Long Vowel targets. The first vowel was [a], [i] or [u] (either short or long), the consonant was [f] (either singleton or geminate), and the second vowel was always [a].

Table 6.5. Experiment 2: minimal triplets

Geminate	Singleton	Long Vowel
[af:a]	[afa]	[a:fa]
[if:a]	[ifa]	[i:fa]
[uf:a]	[ufa]	[u:fa]

The same native speaker of Japanese who recorded the materials for the Identification test recorded multiple tokens of all nine items (i.e., three triplets). The recording, editing, and pairing procedures were identical to those of the materials in Experiment 1.

6.3.1.3 Procedure

In contrast to Experiment 1, participants completed a single block because here, a single place of articulation was used. Other than that, the procedure was identical to Experiment 1.

6.3.2 Results

First, using the results from all experimental pairs, it is examined whether the adoptees performed better than the Dutch control participants in discriminating the Japanese contrasts. Second, using only the results from the Different experimental pairs, Geminate-Singleton, Geminate-Long Vowel, and Singleton-Long Vowel combinations are compared. Finally, the results of the native Korean control participants are compared to the pre-test results of the adoptees and the Dutch control participants.

6.3.2.1 Overall sensitivity

Table 6.6, containing the percentage of correct responses for all experimental pairs, clearly shows that the adoptees and Dutch controls performed equivalently again, on all three tests (see also Table 6.7 for d'). Sixty-five responses with RTs longer than 5,000 ms (0.7 % of all responses) were excluded from the analyses.

Table 6.6. Experiment 2: percentage correct for all experimental pairs (and standard error), separately for Korean adoptees and Dutch controls at pre-, intermediate, and post-tests, and for Korean controls at a single test.

Test	Adoptees	Dutch Controls	Korean Controls
Pre-	91.33 (1.67)	90.96 (1.15)	92.85 (0.90)
Intermediate	94.26 (1.05)	92.23 (1.15)	-
Post-	93.80 (0.86)	93 78 (0.87)	-

An ANOVA on d' was carried out across participants with the variables Test (pre-test, intermediate test, post-test) and Group (adoptee, Dutch control). This revealed no significant main effect of Group and no significant interaction between Test and Group. There was a significant main effect of Test, $F(2, 112) = 4.351$, $p < .05$, $\eta_p^2 = .072$: Participants' sensitivity

was better for the intermediate test than for the pre-test, $F(1, 56) = 4.363$, $p < .05$, $\eta_p^2 = .072$, but there was no significant difference between the intermediate and the post-test.

In short, the adoptees and the Dutch controls improved in the earlier stages of the training and testing period, but there were no significant differences between the groups.

Table 6.7. Experiment 2: *d'* (and standard error), separately for Korean adoptees and Dutch controls at pre-, intermediate, and post-tests, and for Korean controls at a single test. (Higher values of *d'* indicate greater sensitivity.)

Test	Adoptees	Dutch Controls	Korean Controls
Pre-	2.99 (0.18)	3.06 (0.15)	3.00 (0.13)
Intermediate	3.50 (0.16)	3.09 (0.15)	-
Post-	3.38 (0.13)	3.33 (0.15)	-

6.3.2.2 Comparison types

To investigate how the participants perceived the differences between Geminate-Singleton, Geminate-Long Vowel, and Singleton-Long Vowel comparisons, additional analyses were done with the Different experimental pairs only. Proportions of correct responses for the Different experimental pairs were used as dependent variable. Twenty-three responses with RTs longer than 5,000 ms (0.01 % of all responses) were excluded from analysis.

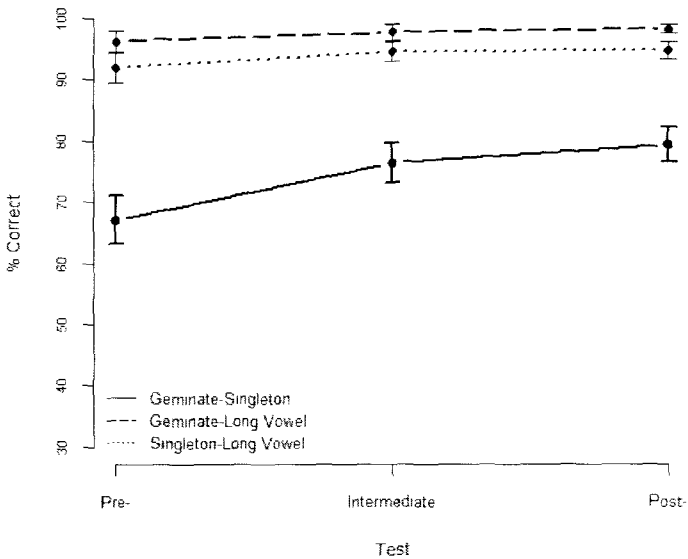

Figure 6.3. Experiment 2: percentage correct for three comparison types for Korean adoptees and Dutch controls, at pre-, intermediate, and post-tests. Error bars represent standard errors.

Figure 6.3 and Table 6.8 show that both groups performed best at the Geminate-Long Vowel comparison, and worst for the Geminate-Singleton comparison, with the Singleton-Long Vowel comparison falling in between. ANOVAs with the variables Test (pre-test, intermediate test, and post-test), Comparison type (Geminates-Singletons, Geminates-Long Vowels, Singletons-Long Vowels), and Group (adoptee and Dutch control) confirmed that there was a significant main effect of Comparison type, $F1(2, 112) = 87.272$, $p < .05$, $\eta_p^2 = .609$; $F2(2, 15) = 15.998$, $p < .05$, $\eta_p^2 = .681$. Follow-up analyses showed that all three comparison types differed significantly from each other (Geminate-Singleton vs. Geminate-Long Vowel: $F1(1, 56) = 100.408$, $p < .05$, $\eta_p^2 = .642$; $F2(1, 10) = 18.745$, $p < .05$, $\eta_p^2 = .652$; Geminate-Singleton vs. Singleton-Long Vowel: $F1(1, 56) = 81.652$, $p < .05$, $\eta_p^2 = .593$; $F2(1,$

10) = 13.395, $p < .05$, $\eta_p^2 = .573$; Geminate-Long Vowel vs. Singleton-Long Vowel: $F1(1, 56)$ = 19.678, $p < .05$, $\eta_p^2 = .260$; $F2(1, 10) = 11.841$, $p < .05$, $\eta_p^2 = .542$).

There was a significant three-way interaction with all variables (i.e., Test, Comparison type, and Group),[18] $F1(4, 224) = 4.475$, $p < .05$, $\eta_p^2 = .074$; $F2(4, 30) = 6.827$, $p < .05$, η_p^2 = .477). For the Geminate-Long Vowel and the Singleton-Long Vowel comparisons, the percentage correct was very high at all tests for both groups. For those comparisons, there were no significant main effects of Test and of Group, and there was no significant interaction between Test and Group. For the more difficult Geminate-Singleton comparison, on the other hand, there was a significant effect of Test, $F1(2, 112) = 6.396$, $p < .05$, $\eta_p^2 = .130$; $F2(2, 10)$ = 10.363, $p < .05$, $\eta_p^2 = .675$, and a significant interaction between Group and Test (Table 6.8), $F1(2, 112) = 5.520$, $p < .05$, $\eta_p^2 = .090$; $F2(2, 10) = 10.363$, $p < .05$, $\eta_p^2 = .675$. Only the adoptees but not the Dutch controls performed significantly better in the intermediate test than the pre-test, $F1(1, 28) = 14.698$, $p < .05$, $\eta_p^2 = .344$; $F2(1, 5) = 27.307$, $p < .05$, η_p^2 = .845, and there was no significant difference between the intermediate and the post-test for either of the groups. Importantly, there was no significant difference between the groups at any of the tests, confirming the analyses of the overall sensitivity.

[18] The main analysis also showed significant main effects of Test and of Comparison type, as well as an interaction between Test and Comparison type ($ps < .05$).

Table 6.8. Experiment 2: percentage correct (and standard error) for Geminate-Singleton, Geminate-Long Vowel, and Singleton-Long Vowel comparisons, separately for Korean adoptees and Dutch controls at pre-, intermediate, and post-tests, and for Korean controls at a single test.

Pairing	Pre-test		Intermediate test		Post-test		
	Adoptees	Dutch Controls	Adoptees	Dutch Controls	Adoptees	Dutch Controls	Korean Controls
Geminate-Singleton	61.3 (5.2)	72.8 (5.9)	80.1 (3 9)	72.5 (5.1)	84.7 (3.3)	74.0 (4.4)	54.6 (6.9)
Geminate-Long Vowel	94.8 (3.0)	97.7 (1.9)	98.3 (1.3)	97.1 (2.3)	98.3 (1 0)	98 3 (1.3)	97 5 (1.4)
Singleton-Long Vowel	93.6 (2.5)	90.2 (4.2)	97.1 (1.4)	92.0 (2.7)	95.4 (2.2)	94.2 (1 9)	94.2 (2.5)
Overall	83.3 (2.9)	86.9 (3.6)	91.9 (1 9)	87.2 (2.8)	92 8 (1.5)	88 8 (1 9)	82.1 (2 7)

6.3.2.3 Korean control participants

The results of the Korean controls (who participated in a single test session) were compared to the pre-test results of the adoptees and the Dutch control participants. First, an ANOVA on *d'* was carried out across participants with the variable Group (adoptee, Dutch control, Korean control). There was no significant main effect of Group. Thus, the Korean controls were no better at discriminating the Japanese contrasts than the adoptees and Dutch controls. Because the Korean controls did not outperform the adoptees and Dutch controls at the pre-test, we did not proceed to compare their results to those of the adoptees and Dutch controls at the post-test.

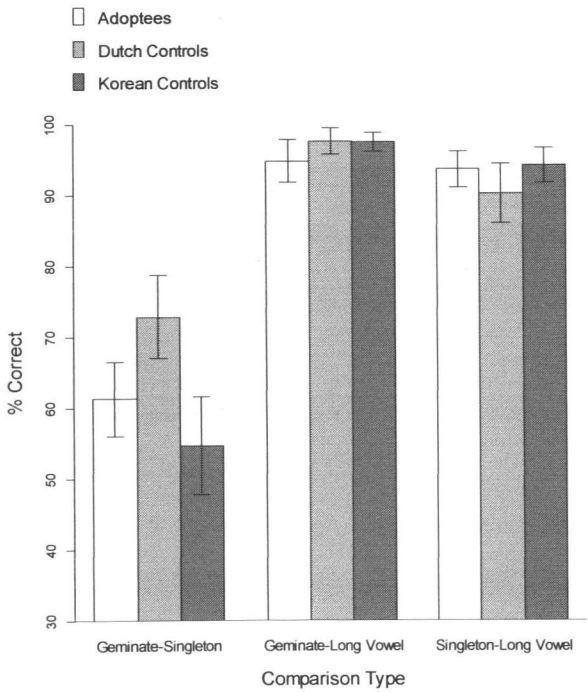

Figure 6.4. Experiment 2: percentage correct for Geminate-Singleton, Geminate-Long Vowel, and Singleton-Long Vowel comparisons, separately for Korean adoptees and Dutch controls at the pre-test, and for Korean controls. Error bars represent standard errors.

Next, additional analyses were done with proportions of correct responses for the Different experimental pairs only. Figure 6.4 shows that the Korean controls performed similarly to the adoptees and the Dutch controls, for all comparison types. ANOVAs with the variables Group (adoptee, Dutch control, Korean control) and Comparison type (Geminate-Singleton, Geminate-Long Vowel, Singleton-Long Vowel) nevertheless showed a significant interaction between Group and Comparison type, $F1(4, 150) = 3.219$, $p < .05$, $\eta_p^2 = .079$. To compare the performance of the Korean controls to that of the adoptees and of the Dutch controls, 6 *t*-tests across participants and across items were carried out (3 comparison types * 2 groups), using Bonferroni correction. None of the comparisons showed a significant difference. That is, the native Korean participants did not perform any different from the

adoptees and the Dutch controls in any of the comparisons. As Figure 6.4 shows, for the Geminate-Long Vowel and Singleton-Long Vowel comparisons, the lack of a difference might be due to a ceiling effect. Note that for the Geminate-Singleton comparison, the Korean controls did not outperform the adoptees and Dutch controls either; to the contrary, there was a non-significant trend in the opposite direction.

In short, for all participants, the most difficult comparison was the Geminate-Singleton contrast. This is consistent with the results from Chapter 5, where identification was worst for the Geminates, intermediate for Singletons, and best for the Long Vowel targets. Thus, even though Korean does not have a vowel length contrast, all participants were good at perceiving the vowel length difference, and less good at perceiving the consonant length difference.

6.4 Discussion

In the present study, it was investigated whether the Korean adoptees outperformed the Dutch control participants on *discrimination* of the Korean stop contrasts (Experiment 1), and of the Japanese length combination (Experiment 2). Importantly, the adoptees did not perform better than the Dutch controls on the Korean or Japanese contrasts — as was consistently found both in the analysis of d' scores, that were calculated on the basis of full data set (i.e., Same and Different experimental trials), and in the analysis of proportions correct for the Different experimental trials only. The results thus indicate that the adoptees and the Dutch control participants did not differ in their discrimination of the target contrasts.

From the lack of a difference between those groups in Experiment 2, no strong conclusions can be drawn. For the Japanese length combination, the Korean control participants did not perform any better than the adoptees and Dutch controls. For the Geminate-Long Vowel comparison and the Singleton-Long Vowel comparison, which were

easy to discriminate for all three groups, the lack of a difference might be due to a ceiling effect. For the crucial Geminate-Singleton comparison, that was hypothesized to be similar to the Korean fortis-lenis contrast and was expected to lead to better performance for the Korean controls than for the other two groups, there was no ceiling effect, and yet there was no benefit for the Korean controls over the other groups either. In fact, there was even a non-significant trend in the opposite direction, with a lower score for the Korean controls than for the other two groups. Apparently, the similarity between the Japanese geminate-singleton contrast and the Korean fortis-lenis contrast did not aid the Korean native listeners' discrimination of the Japanese targets. Therefore, it seems likely that the adoptees' early experience to Korean should not lead to a difference between the adoptees and the Dutch controls. Note that only the adoptees but not the Dutch controls showed a significant improvement for the Geminate-Singleton comparison. It is hard, however, to draw any strong conclusions from this, because the adoptees started with a lower score than the Dutch controls in the pre-test (61.3% versus 72.8%), and because the difference between the groups was not significant for any of the tests. Therefore it cannot be concluded that the adoptees' previous experience with Korean induced their significant improvement for the Geminate-Singleton contrast. Thus, the results from Experiment 2 unfortunately do not provide any direct insights into the adoptees' memory of Korean phonology.

The lack of a difference between adoptees and Dutch controls in Experiment 1, on the other hand, does provide such insights. As expected, Korean control participants performed excellently at discriminating the Korean contrasts, and strongly outperformed the adoptees and Dutch controls at all places of articulation and for all comparison types. The adoptees, however, did not outperform the Dutch controls. This further elucidates the findings from previous chapters, where the adoptees did outperform the Dutch controls in *identifying* both the Korean contrasts and the Japanese contrasts after the training. The present results suggest

that the observed benefits for the adoptees over the Dutch controls in the identification tasks did not come from the adoptees' superior discrimination of the phonemes. Although it is unknown what aspects of phoneme perception the identification and discrimination paradigms test exactly (see e.g., Broersma et al., 2013; Gerrits & Schouten, 2004; Sadakata & McQueen, 2013), we can speculate that the results of the identification tasks might suggest that the adoptees were better than the Dutch controls at forming mental representations of phonetic categories for the target sounds, and/or at assigning the target sounds that they heard to those phonetic categories.

Similarly, the Korean controls did outperform the other two groups in identification of the Japanese contrasts (Chapter 5) but not in discrimination of the same contrasts (as shown in the present chapter).

Even though Identification and Discrimination tasks have been proposed to tap into different perceptual processes (Broersma et al., 2013; Gerrits & Schouten, 2004; Sadakata & McQueen, 2013), the identification training had a clear effect on the discrimination of the target contrasts. In both Experiments 1 and 2, there was an improvement at the early stages of the testing procedure for both the adoptees and Dutch controls (with a significant improvement between the pre-test and the intermediate test, but not between the intermediate test and the post-test). However, the improvement was relatively small (see Figures 6.1 and 6.3). Aside from the fact that the participants started out with relatively high percentages correct for most contrasts, another reason for the limited improvement might be that the identification and discrimination tasks exploit different perceptual processes. An interesting question is whether training with a discrimination task would lead to greater improvement on a discrimination test, and if that might even affect the (lack of a) difference between adoptees and Dutch controls. If the adoptees and controls are trained to enhance their perceptual sensitivity to the contrasts under study with a discrimination task, and tested with the same

task, it is conceivable that the adoptees might show better perceptual sensitivity for their birth-language phonology than control participants. Obviously, further research would be needed to investigate this possibility.

7 General Discussion

International adoptees have unique experiences with respect to language acquisition. While they are in the process of acquiring their first language, they are suddenly cut off from that language entirely, and are faced with the task of acquiring another language. Accordingly, they rapidly stop using the birth language (Isurin, 2000; Nicoladis & Grabois, 2002), and ultimately become monolinguals of the language of their new environment. Does this mean that international adoptees completely forget the birth language, such that even no implicit memories of it are left by the time they have reached adulthood? This dissertation has aimed to answer that question by investigating Korean adoptees in the Netherlands who were adopted by Dutch-speaking families in early childhood, and who were adults at the time of testing. The performance of the Korean adoptees on a range of tests was compared with that of a control group of Dutch native speakers who had no prior experience with Korean. Another control group of Korean native speakers provided a baseline for Korean native performance. Importantly, this is the first study that investigates *production* of birth language phonemes by international adoptees, and it is also the first to assess memory of birth language phonology for adult adoptees with an experimentally controlled retraining procedure.

Previous studies have shown that after a sudden reduction in exposure to a *heritage* language, phonological knowledge gained in early childhood can still persist into adulthood and can help in relearning to perceive phoneme contrasts of that language later in life (J. S. Oh et al., 2003; Tees & Werker, 1984). In those studies, participants kept some (if only

limited) contact with the language. This is crucially different from international adoptees, for whom contact with their birth language is generally completely lost after adoption. The question thus remains whether international adoptees retain any memories of the phonology of their birth language into adulthood.

In Chapter 3, we addressed this issue by investigating whether the Korean adoptees outperformed the Dutch control participants when (re)learning to identify Korean consonant contrasts. The adoptees and Dutch controls were trained to identify the Korean fortis-lenis-aspirated alveolar stop contrast [t*, t, t^h], in a sequence of 13 perceptual training blocks (Chapter 2). They were tested on their identification of those stops in a pre-, intermediate, and post-test (Chapter 3). The results have shown that the adoptees were faster than the Dutch controls in (re)learning to identify the trained contrast. The adoptees and Dutch controls performed equivalently in the pre-test but, crucially, in the intermediate test, the adoptees outperformed the controls in the identification of the contrast. In the post-test, the control participants caught up with the adoptees so that the two groups performed equivalently again. Similar results were found when the adoptees and Dutch controls were tested on the generalization of what they had learned to similar contrasts at two novel places of articulation, namely the bilabial [p*, p, p^h] and velar [k*, k, k^h] fortis-lenis-aspirated contrasts. Again, there was no difference between adoptees and Dutch controls at the pre-test or at the post-test, whereas the adoptees outperformed the Dutch controls at the intermediate test.

These results have thus demonstrated that phonological knowledge of the birth language can be preserved despite several decades of disuse, and that this knowledge can facilitate (re)learning to recognize phoneme contrasts from the birth language. The finding that there was no difference between adoptees and Dutch controls at the pre-test is in line with previous studies showing no difference between adoptees and controls in phoneme perception of the birth language without any training (Pallier et al., 2003; Ventureyra et al.,

2004). The finding that the adoptees outperformed the Dutch controls after some training is in line with previous work (discussed in more detail in Chapter 1) providing careful hints that even after a complete cut-off, the remnants of a childhood language might become accessible with re-exposure, and lead to a benefit in relearning the phonology of the language (Bowers et al., 2009; Hyltenstam et al., 2009; J. S. Oh et al., 2010).

In Chapter 4, we explored whether relearning advantages similar to those found in the domain of perception can also be found in the domain of production. To that end, the adoptees' production of the fortis-lenis-aspirated contrasts (at alveolar, bilabial, and velar place of articulation) was compared to that of the Dutch controls. Productions were collected twice, at a pre-test after the first perceptual training block and at a post-test after the last (13^{th}) perceptual training block. The productions were evaluated by native listeners of Korean, with a phoneme identification task (Chapter 4.2) and a phoneme rating task (Chapter 4.3). The results showed that both the adoptees and the Dutch controls improved their pronunciation of the Korean contrasts following the training but, importantly, the adoptees improved more than the Dutch controls. The adoptees' utterances at the post-test were identified more accurately, and evaluated as better pronunciations than those from the Dutch controls.

These results show that the adoptees' early experience led to benefits in the domain of speech production as well. Previous studies demonstrated that early experience with a discontinued heritage language led to a better pronunciation of phonemes of that language later in life (Au et al., 2002; Knightly et al., 2003; J. S. Oh et al., 2003). The present results thus extend those findings, by showing that adoptees, who experienced a complete disconnection from their birth language, also produced the sounds of their birth language more accurately than novice learners later in life.

In Chapter 5, it was demonstrated that the adoptees' relearning benefits were not restricted to the specific phonemes of the birth language, but extended to novel but partially

similar contrasts. The adoptees and Dutch controls were trained in and tested on identification of a Japanese long versus short consonant contrast that was phonologically partially similar to the Korean fortis versus lenis consonant contrast. Indeed, native Korean control participants outperformed the adoptees and Dutch controls in the identification of the Japanese contrast before the training, confirming the validity of the contrast as a proper target to assess the effect of the adoptees' early experience with Korean. Importantly, the adoptees outperformed the Dutch controls in identifying the geminate consonants, in all three tests.[19] This suggests that their remembered knowledge of Korean phonology was readily generalizable to partially similar but novel contrasts.

This finding however also raises a new question: Did the adoptees outperform the control participants only because of the similarity between the Japanese and Korean contrasts, or would they also outperform the controls when learning phonological contrasts that do not contain any similarity to the phonological properties of the birth language? It is conceivable that international adoptees are good at learning new phonology *in general*, due to their unique experience of successively acquiring two first languages during the sensitive period for language learning (Lenneberg, 1967). Future studies are needed to investigate this possibility.

In Chapter 6, the adoptees' (re)learning advantages were further assessed using a different paradigm, namely discrimination. The experiments reported in the previous chapters on phoneme perception (Chapters 3 and 5) made use of identification tasks. It has been shown that the identification and discrimination tasks often yield divergent results, and the tasks have been proposed to tap into different perceptual processes (Broersma et al., 2013; Gerrits & Schouten, 2004; Sadakata & McQueen, 2013). The adoptees and Dutch controls were tested on discrimination of the same Korean (Experiment 6.1) and Japanese contrasts

[19] The adoptees outperformed the Dutch controls already at the pre-test for the Japanese (Chapter 5) but not for the Korean stimuli (Chapter 3). As discussed in Chapter 5, this might be due to the fixed order of the testing, with the Korean stimuli always being tested before the Japanese stimuli.

(Experiment 6.2). There was no difference between the adoptees and Dutch controls in discriminating the Korean contrasts and the Japanese contrast, at any of the pre-, intermediate, or post-tests. The finding that there was no difference between the adoptees and Dutch controls in the discrimination of the target contrasts suggests that the difference between the groups observed in the identification tasks in the previous chapters might be related to the formation and/or processing of phonetic categories, which might play a more important role in identification than in discrimination.

In Experiment 6.2, only the adoptees and not the Dutch controls showed a significant improvement in distinguishing between Japanese geminates and singletons (namely from the pre-test to the intermediate test). As the geminate-singleton contrast is phonologically to some extent similar to the Korean fortis-lenis contrast in intervocalic position, the significant improvement for the adoptees (but not for the controls) could be taken as the result of the adoptees' previous experience with Korean. Note however that the adoptees started out with a much *lower* score than the Dutch controls in the pre-test (61.3% versus 72.8%). Adoptees then obtained a numerically higher score than the Dutch controls in the intermediate test (80.1% versus 72.5%). The difference between the groups was not significant at any of the tests. The fact that the adoptees had such a low score in the pre-test makes it hard to draw strong conclusions about any possible benefits of their early experience with Korean for their perceptual sensitivity to this contrast. To assess whether more convincing evidence for such benefits can be obtained, further studies are required.

The Dutch control group in the experiments in this thesis consisted of two types of participants. Half of the Dutch controls were siblings or partners of a Korean adoptee; the other half had no such relationship with Korean adoptees. The 'related' subgroup was included because they were argued to provide the best possible match with the Korean adoptees in terms of socio-economic background, interest in Korea or the Korean language,

and level of motivation for participation. Because of the limited availability of such participants, 'unrelated' Dutch controls were also included. In order to validate the inclusion of such 'unrelated' Dutch controls, they should not perform more poorly than the 'related' Dutch controls (as that would give support to the null hypothesis that there was no difference between adoptees and Dutch controls). Importantly, the 'unrelated' controls performed as well as the 'related' controls (Chapter 3 and 5), and even outperformed them in some conditions (Chapter 4). This suggests that the Dutch control group used in this study can be presumed as appropriate as a control group consisting entirely of 'related' control participants.

In our sample of adoptees, age of adoption ranged from three months to 5:10 years. In Chapters 3, 4, and 5, it was assessed whether age of adoption (i.e., length of experience with the birth language before adoption) accounted for the adoptees' performance. Diverse analyses were carried out, and provided consistent evidence that, surprisingly, there was no effect of age of adoption on the adoptees' performance: There was no significant correlation between age of adoption and the adoptees' performance at any of the tests. ANCOVAs using a median split on age of adoption showed that there was no difference in identification performance between those who were adopted before five months of age and those who were adopted after 17 months of age. Multiple regression analyses confirmed that age of adoption did not affect the adoptees' production of Korean stops either.

Taken together, these findings have clearly demonstrated that the length of previous experience with the birth language had no influence on the adoptees' perception and production of the contrasts of the language later in life. Possibly, the long time that had elapsed since the adoption (about 24 to 40 years, see Chapter 2.1) might have removed any potential effects of age of adoption. Similar to our findings, a previous study with adult adoptees did not find a correlation between age of adoption and the adoptees' identification accuracy for birth-language contrasts either (J. S. Oh et al., 2010). On the other hand, a study

with adopted *children*, who had been adopted more recently (about five to 15 years prior to the study), showed a trend that later adopted children tended to perform more accurately in the discrimination of contrasts of their birth language than earlier adopted children (Singh et al., 2011).[20]

Importantly, our results showed that only a few months of experience with the birth language in infancy was enough to lead to long-lasting knowledge about the sounds of that language. The subgroup of adoptees who were adopted prior to the age of five months outperformed the Dutch control participants in the identification of the Korean contrasts (Chapter 3), and of the Japanese contrast (Chapter 5). This is in line with tentative evidence for a relearning benefit from a previous study where most (i.e., 8/12) of the adopted participants were adopted prior to the age of six months (J. S. Oh et al., 2010).[21]

These results are intriguing from the viewpoint of infants' phonological acquisition. It has been assumed in the field of infant studies that the phonological system of the native language begins to emerge around six months of age (see e.g., Kuhl, 2004; Werker & Tees, 1984). At that age, infants show clear evidence of tuning into the phoneme categories of their native language. Thus, the adoptees who were adopted before the age of five months had not yet reached the age where clear signs of language-specific phoneme perception are evident, and certainly did not have a fully-developed phonological system that was attuned to Korean. Nonetheless, later in life they had a definite advantage over novice learners when learning to recognize phonemes from (or similar to) the birth language. Thus, three to five months of

[20] Note that in that study, the effect of age of adoption could not be separated from that of time elapsed since adoption. In order to tease the two factors apart, more data with different samples of adoptees are necessary. Note however that a confound with a third variable, namely current age, cannot be avoided, as age of adoption and time since adoption add up to current age.

[21] As described in Chapter 1, when overall accuracy was analyzed, the adoptees did not outperform the control participants in identifying their birth-language contrasts, but they seemed to perform better than the controls at some particular phonemes (J. S. Oh et al., 2010).

early exposure to the birth language endowed the adoptees with (re)learning advantages in adulthood.

Indeed, even if the first empirical evidence for language-specific listening is found around six months of age, there is also ample evidence that language acquisition *begins* much earlier than that. First, learning about the first language begins even before birth (see Cutler, 2012, pp. 259-301, for a review). E.g., newborn infants prefer to listen to the voice of their mother over other female voices (DeCasper & Fifer, 1980), and to a passage which was presented to them during the prenatal period over a novel passage (Decasper & Spence, 1986), indicating that they hear, learn, and remember something about their maternal language before birth. Second, neonates and infants younger than three months old consistently show an ability to encode, retain, and retrieve auditory information (Benavides-Varela et al., 2012; Dehaene-Lambertz et al., 2002). Furthermore, they have been shown to use the left temporal and right frontal cortex to process auditory information, revealing that an adult-like auditory memory system is already functional in neonates (Benavides-Varela et al., 2012; Dehaene-Lambertz et al., 2002). Third, infants are sensitive to phoneme categories immediately after birth, as shown by an increase in brain activity at a change of the phonemic category of syllables they hear, suggesting that they are in the process of developing a phonological system for the native language (Dehaene-Lambertz & Peña, 2001). Taken together, those studies show that linguistic development starts before birth, and infants under the age of five months might have started to accumulate substantial knowledge of their native phonology. Our results suggest that indeed, adoptees did develop phonological knowledge of the birth language in the first five months of life, and moreover retained that knowledge into adulthood.

To conclude, this study has been the first to investigate memory of birth language phonology in adult adoptees with an experimentally controlled retraining procedure. This dissertation has demonstrated that phonological knowledge of the birth language that

international adoptees obtained in early childhood can be preserved into adulthood even if the adoptees were not exposed to the language for several decades. Adoptees were shown to benefit from this persistent knowledge of the birth language phonology when relearning to perceive *and* produce phonemic contrasts of that language, when generalizing what they had learned to similar but untrained contrasts at other places of articulation, and when learning new contrasts of a different language with some similarities to the birth-language phonology. Thus, relearning benefits for adoptees were found on different levels of phonological abstraction.

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Appendix A

Materials used in the word recognition task (*and English translations*)

Korean word	Dutch word		
	Correct answer	Alternative 1	Alternative 2
mamma (*food*)	eten	bal (*ball*)	neus (*nose*)
kkakkung (*peekaboo*)	kiekeboe	luier (*diaper*)	op (all gone)
jjakjjakkung (*clap your hands*)	in je handen klappen	slaap lekker (*good night*)	dansen (*dance*)
manse (*hurray*)	hoera	fles (*bottle*)	mmm lekker (*yum yum*)
mokyok (*bath*)	badje	oh oh (*uh oh*)	baby (*baby*)
swi (*pee*)	plas	sap (*juice*)	kusje (*kiss*)
eungka (*poo*)	poep	melk (*milk*)	schoen (*shoe*)
hajima (don't do that)	niet doen	buiten (*outside*)	beker (*cup*)
jueo (*give*)	geef	hoi (*hi*)	boek (*book*)
jiji (*dirty*)	vies	knuffel (*hug*)	koekje (*cookie*)

Appendix B

Materials, Chapter 2 (training) and Chapter 3 (identification test); Korean stops.

25 Minimal triplets for each place of articulation

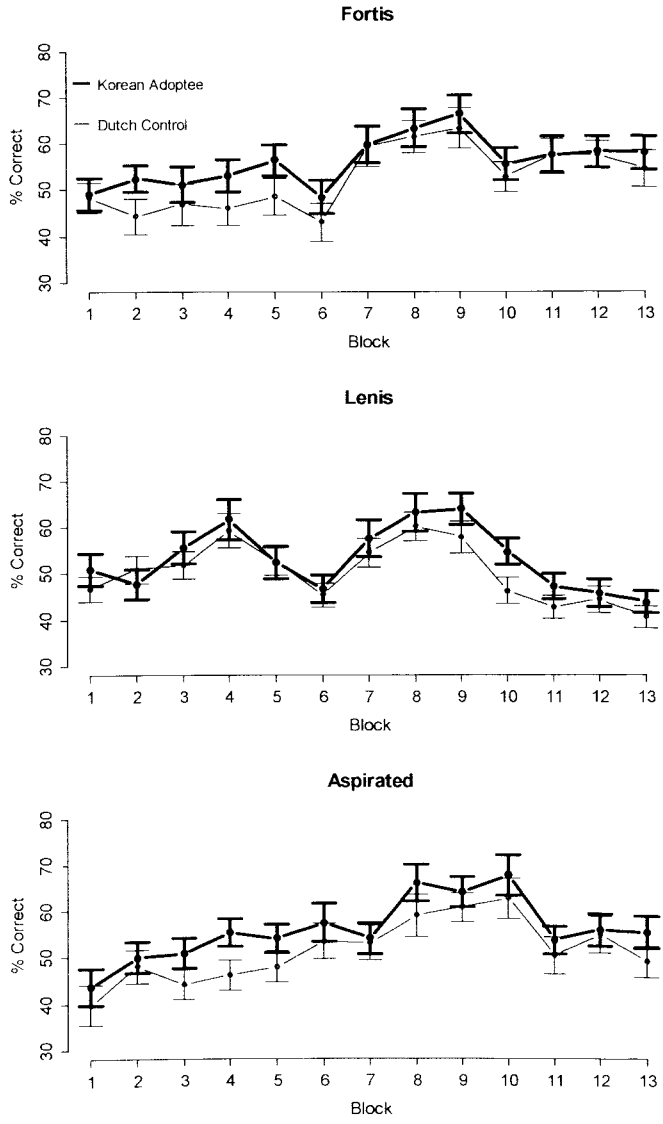
Place of articulation	Vowel	Second syllable	Triplets		
			fortis	lenis	aspirated
Alveolar (training and test)	[a]	[ra]	t*ara	tara	t^hara
		[he]	t*ahe	tahe	t^hahe
		[mi]	t*ami	tami	t^hami
		[tjo]	t*atjo	tatjo	t^hatjo
		[su]	t*asu	tasu	t^hasu
	[e]	[ra]	t*era	tera	t^hera
		[he]	t*ehe	tehe	t^hehe
		[mi]	t*emi	temi	t^hemi
		[tjo]	t*etjo	tetjo	t^hetjo
		[su]	t*esu	tesu	t^hesu
	[i]	[ra]	t*ɪra	tira	t^hɪra
		[he]	t*ihe	tihe	t^hihe
		[mi]	t*imi	timi	t^hɪmi
		[tjo]	t*itjo	tɪtjo	t^hitjo
		[su]	t*ɪsu	tisu	t^hɪsu
	[o]	[ra]	t*ora	tora	t^hora
		[he]	t*ohe	tohe	t^hohe
		[mi]	t*omi	tomɪ	t^homi
		[tjo]	t*otjo	totjo	t^hotjo
		[su]	t*osu	tosu	t^hosu
	[u]	[ra]	t*ura	tura	t^hura
		[he]	t*uhe	tuhe	t^huhe
		[mi]	t*umi	tumi	t^humi
		[tjo]	t*utjo	tutjo	t^hutjo
		[su]	t*usu	tusu	t^husu
Bilabial (test)	[a]	[ra]	p*ara	para	p^hara
		[he]	p*ahe	pahe	p^hahe
		[mi]	p*amɪ	pami	p^hamɪ
		[tjo]	p*atjo	patjo	p^hatjo
		[su]	p*asu	pasu	p^hasu
	[e]	[ra]	p*era	pera	p^hera
		[he]	p*ehe	pehe	p^hehe
		[mɪ]	p*emɪ	pemi	p^hemi
		[tjo]	p*etjo	petjo	p^hetjo
		[su]	p*esu	pesu	p^hesu
	[i]	[ra]	p*ɪra	pɪra	p^hɪra
		[he]	p*ihe	pɪhe	p^hɪhe
		[mɪ]	p*ɪmɪ	pimi	p^himɪ
		[tjo]	p*ɪtjo	pitjo	p^hitjo
		[su]	p*ɪsu	pɪsu	p^hisu

	[o]	[ra]	p*ora	pora	p^{h}ora
		[he]	p*ohe	pohe	p^{h}ohe
		[mi]	p*omi	pomi	p^{h}omi
		[tjo]	p*otjo	potjo	p^{h}otjo
		[su]	p*osu	posu	p^{h}osu
	[u]	[ra]	p*ura	pura	p^{h}ura
		[he]	p*uhe	puhe	p^{h}uhe
		[mi]	p*umi	pumi	p^{h}umi
		[tjo]	p*utjo	putjo	p^{h}utjo
		[su]	p*usu	pusu	p^{h}usu
Velar (test)	[a]	[ra]	k*ara	kara	k^{h}ara
		[he]	k*ahe	kahe	k^{h}ahe
		[mi]	k*ami	kami	k^{h}ami
		[tjo]	k*atjo	katjo	k^{h}atjo
		[su]	k*asu	kasu	k^{h}asu
	[e]	[ra]	k*era	kera	k^{h}era
		[he]	k*ehe	kehe	k^{h}ehe
		[mi]	k*emi	kemi	k^{h}emi
		[tjo]	k*etjo	ketjo	k^{h}etjo
		[su]	k*esu	kesu	k^{h}esu
	[i]	[ra]	k*ira	kira	k^{h}ira
		[he]	k*ihe	kihe	k^{h}ihe
		[mi]	k*imi	kimi	k^{h}imi
		[tjo]	k*itjo	kitjo	k^{h}itjo
		[su]	k*isu	kisu	k^{h}isu
	[o]	[ra]	k*ora	kora	k^{h}ora
		[he]	k*ohe	kohe	k^{h}ohe
		[mi]	k*omi	komi	k^{h}omi
		[tjo]	k*otjo	kotjo	k^{h}otjo
		[su]	k*osu	kosu	k^{h}osu
	[u]	[ra]	k*ura	kura	k^{h}ura
		[he]	k*uhe	kuhe	k^{h}uhe
		[mi]	k*umi	kumi	k^{h}umi
		[tjo]	k*utjo	kutjo	k^{h}utjo
		[su]	k*usu	kusu	k^{h}usu

Appendix C

Results, Chapter 2 (training); Korean stops.

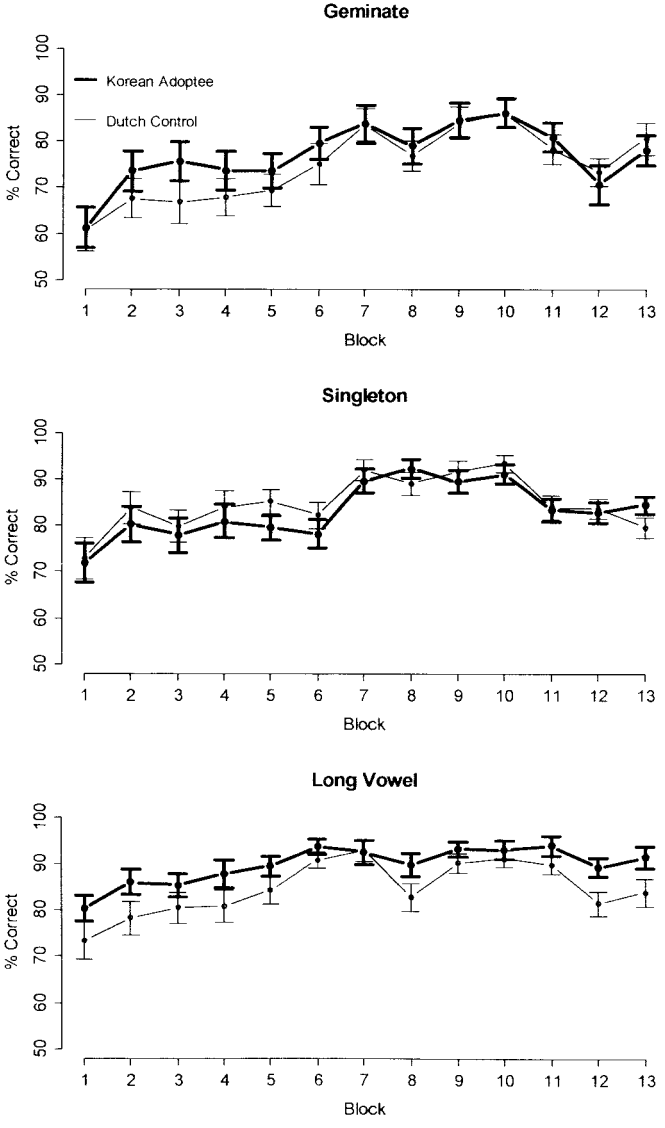
Percentage correct for the 13 training blocks, separately for fortis, lenis, and aspirated targets. Error bars represent standard errors.



Appendix D

Results, Chapter 2 (training); Japanese length combination.

Percentage correct for the 13 training blocks, separately for Geminate, Singleton, and Long Vowel targets. Error bars represent standard errors.



Nederlandse samenvatting

Het herontdekken van een vergeten taal

Wie als kind internationaal geadopteerd wordt doet ook op taalkundig gebied unieke ervaringen op: terwijl de eerstetaalverwerving in volle gang is wordt het contact met die taal plotseling volledig verbroken en wordt het kind voor de taak gesteld een geheel andere taal te leren. Doorgaans stoppen adoptiekinderen dan ook snel de eerste taal te gebruiken (Isurin, 2000; Nicoladis & Grabois, 2002) en zijn ze al gauw niet meer te onderscheiden van moedertaalsprekers van de taal van hun nieuwe leefomgeving. Maar betekent dit dat internationaal geadopteerden de taal van hun land van herkomst volledig vergeten, en dat er tegen de tijd dat ze volwassen zijn geworden zelfs geen impliciete herinneringen aan deze taal meer over zijn? Op deze vraag wil dit proefschrift een antwoord geven. Daartoe zijn Koreaanse geadopteerden in Nederland onderzocht die als kind zijn geadopteerd door Nederlandstalige gezinnen en die volwassen waren ten tijde van het onderzoek. Deze geadopteerden namen deel aan een serie fonologische tests. Hun resultaten zijn vergeleken met die van een controlegroep van niet-geadopteerde Nederlanders die in hun kindertijd geen ervaring hebben opgedaan met het Koreaans. Daarnaast zijn de resultaten van beide groepen vergeleken met die van een controlegroep van niet-geadopteerde Koreaanse deelnemers die in Korea zijn geboren en getogen. In deze studie werd onderzocht of herinneringen aan de taal van het land van herkomst konden worden geactiveerd door middel van hertraining. Dit is het eerste onderzoek waarin een experimentele trainingsprocedure is gebruikt bij volwassen geadopteerden. Verder is dit het eerste onderzoek waarbij naast het herkennen van klanken ook het uitspreken van klanken uit de taal van het land van herkomst bij geadopteerden is onderzocht.

Voor het experiment dat wordt beschreven in hoofdstuk 3 werden de Koreaanse geadopteerden en de Nederlandse controleproefpersonen getraind in het identificeren van de Koreaanse alveolaire fortis, lenis, en geaspireerde klanken [t*, t, t^h], in een serie van dertien trainingsblokken (zie hoofdstuk 2 voor details). In een pretest, een tussentijdse test en een posttest werden de deelnemers getest op hun identificatie van de getrainde alveolaire klanken en van vergelijkbare bilabiale ([p, p*, p^h]) en velaire ([k, k*, k^h]) fortis, lenis en geaspireerde klanken waarop ze niet waren getraind. De resultaten laten zien dat de geadopteerden en de Nederlandse controleproefpersonen in de pretest even goed waren in het identificeren van de klanken, maar dat de geadopteerden in de tussentijdse test beter waren in het identificeren van de klanken dan de controleproefpersonen; dat gold zowel voor de klanken waarop ze getraind waren als voor de vergelijkbare maar niet-getrainde klanken. In de posttest hadden de controleproefpersonen de geadopteerden weer ingehaald en was er geen verschil meer tussen beide groepen. Deze resultaten laten zien dat kennis van de fonologie van de taal van het land van herkomst bewaard kan blijven, zelfs als deze taal decennialang niet wordt gebruikt, en dat deze kennis kan helpen bij het leren herkennen van de klanken van deze taal.

In hoofdstuk 4 wordt onderzocht of geadopteerden ook een voorsprong hebben bij het leren *uitspreken* van de klanken van de taal van het land van herkomst. Om dat te onderzoeken werden de geadopteerden en de Nederlandse controleproefpersonen vergeleken op hun uitspraak van de fortis, lenis en geaspireerde klanken (zowel alveolaire als bilabiale en velaire klanken). Ze produceerden de klanken in een pretest na het eerste trainingsblok en in een posttest na het laatste trainingsblok. Hun uitingen werden vervolgens geëvalueerd door Koreaanse moedertaalsprekers, met een foneemidentificatietaak (hoofdstuk 4.2) en een foneembeoordelingstaak (hoofdstuk 4.3). De resultaten laten zien dat de uitspraak van zowel de geadopteerden als de Nederlandse controleproefpersonen verbeterde door de training, maar dat de geadopteerden meer vooruit gingen dan de controleproefpersonen. In de posttest

werden hun klanken beter herkend (in de foneemidentificatietaak) en positiever beoordeeld (in de foneembeoordelingstaak) dan die van de controlegroep. Ook bij het uitspreken van Koreaanse klanken hadden de geadopteerden dus profijt van hun vroege ervaringen met de Koreaanse taal.

Hoofdstuk 5 onderzocht of de voorsprong die de geadopteerden hadden bij het leren identificeren van spraakklanken alleen gold voor de precieze fonemen die ze in hun kindertijd hadden gehoord, of ook voor klanken uit een andere taal die enige overlap vertoonden met de Koreaanse klanken. De geadopteerden en Nederlandse controleproefpersonen werden getraind en getest in het herkennen van Japanse lange en korte medeklinkers die fonologisch enigszins overeenkomen met de Koreaanse fortis en lenis medeklinkers (en die voor de controlegroep van niet-geadopteerde Koreaanse moedertaalsprekers inderdaad relatief gemakkelijk te herkennen bleken te zijn). Wederom waren de resultaten van de geadopteerden beter dan die van de Nederlandse controledeelnemers, ditmaal op alle testmomenten. Deze resultaten wijzen erop dat de kennis die de geadopteerden hadden van de fonologie van het Koreaans kon worden ingezet voor het leren herkennen van gedeeltelijk vergelijkbare maar nieuwe klanken uit een andere taal.

Hoofdstuk 6 onderzocht opnieuw het leren herkennen van spraakklanken, maar ditmaal met een ander experimenteel paradigma, namelijk de foneemdiscriminatietaak. Foneemdiscriminatie- en - identificatietaken (zoals gebruikt in de hoofdstukken 3 en 5) laten vaak verschillende uitkomsten zien en er wordt aangenomen dat ze verschillende soorten fonologische processen aanspreken (e.g., Broersma, Dediu, & Choi, 2013; Gerrits & Schouten, 2004; Sadakata & McQueen, 2013). De geadopteerden en de Nederlandse controleproefpersonen werden getest op het discrimineren van de Koreaanse klanken (hoofdstuk 6.1) en van de Japanse klanken (hoofdstuk 6.2). In tegenstelling tot de voorgaande hoofdstukken lieten de resultaten ditmaal geen verschillen zien tussen beide groepen. Dit

suggereert dat de verschillen die werden gevonden met de foneemidentificatietaak in hoofdstuk 3 en 5 wellicht te maken hebben met het vormen of gebruiken van fonetische categorieën, iets wat waarschijnlijk een belangrijkere rol speelt bij foneemidentificatie- dan bij foneemdiscriminatietaken.

Een belangrijke uitkomst van dit onderzoek is dat het voordeel bij het leren herkennen en produceren van spraakklanken niet alleen gold voor de geadopteerden die op wat latere leeftijd waren geadopteerd, maar ook voor de geadopteerden die pas drie tot vijf maanden oud waren ten tijde van hun adoptie. Baby's van deze leeftijd hebben nog geen volledig ontwikkeld fonologisch systeem. Niettemin blijkt uit deze studie dat ze op die leeftijd al genoeg weten van de fonologie van hun moedertaal om er decennia later een voorsprong aan over te houden voor het herleren van de klanken van die taal en van enigszins vergelijkbare klanken uit een andere taal.

Samenvattend is dit de eerste studie die herinneringen aan de fonologie van de taal van het land van herkomst heeft onderzocht bij volwassen geadopteerden door gebruik te maken van een experimentele trainingsprocedure. Uit de experimenten die zijn beschreven in dit proefschrift blijkt dat de kennis die internationaal geadopteerden als kind hebben opgedaan van de fonologie van de taal van het land van herkomst behouden kan blijven tot op volwassen leeftijd, zelfs als de geadopteerden decennialang geen enkel contact met deze taal hebben gehad. Koreaanse geadopteerden bleken beter te zijn dan de Nederlandse niet-geadopteerde controlegroep in het leren herkennen én uitspreken van Koreaanse klanken, in het generaliseren van wat ze tijdens de training hadden geleerd naar vergelijkbare maar niet-getrainde klanken, en in het generaliseren van deze kennis naar enigszins vergelijkbare klanken uit een andere taal (Japans). De geadopteerden hadden dus een voorsprong bij het herleren van de klanken van het Koreaans op verschillende niveaus van fonologische abstractie.

한국어 요약

국제 입양인들의 모국어 습득 과정은 특별하다.생애 처음으로 습득하던 모국어의 습득이 입양으로 인하여 갑자기 중단되고, 입양된 곳에서 사용되는 언어를 새로운 모국어로 습득해야 하는 과제에 직면하게 된다. 그 결과, 출생 언어의 사용이 입양 후 빠르게 중단되고 (Isurin, 2000; Nicoladis & Grabois, 2002), 결국은 새로운 환경에서 사용되는 언어가 그들의 모국어로 자리잡는다. 국제 입양인들이 성인이 되었을 때, 과연 그들은 출생 언어에 대한 모든 기억을 완전히 잊게되는 것일까? 본 박사 논문에서는 성인이 된 국제 입양인들의 출생 언어에 대한 지식이 완전히 사라졌는지, 아니면 성인기에도 여전히 존재하는 지식이 있는지 알아보았다. 본 연구는 네덜란드인 가정(네덜란드에 거주)으로 영유아기에 입양되었고 본 연구에 참여할 당시엔 성인인 한국 출신 입양인들을 대상으로 실시하였다. 이 한국 입양인 집단과 네덜란드어를 모국어로 하는 성인 네덜란드인 통제 집단이 일련의 실험 과제를 수행하였고, 두 집단의 수행 결과가 비교되었다.

3 장에 서술된 실험에서, 한국 입양인 집단과 네덜란드인 통제 집단은 한국어의 치경 경음-평음-격음 [ㄸ, ㄷ, ㅌ]을 듣고 식별(identification: 소리 자극을 듣고 경음, 평음, 격음 중 하나를 답으로 선택하는 과제)하는 지각 훈련을 13 번 받았다 (훈련 절차에 대한 자세한 사항은 2 장에 기술됨). 실험 참가자들의 치경 경음-평음-격음에 대한 식별 능력은 사전 검사, 중간 검사, 사후 검사를 통해 측정되었고, 훈련을 받지 않은 양순 경음-평음-격음 [ㅃ, ㅂ, ㅍ]과 연구개 경음-평음-격음 [ㄲ, ㄱ, ㅋ]에 대한 식별 능력도 이 세 번의 실험에서 함께 측정되었다. 그 결과, 사전 검사에서는 한국 입양인 집단과 네덜란드인 통제 집단 간에 차이가 없었으나,

중간 검사에서 입양인 집단이 통제 집단에 비해 수행을 더 잘하였다. 사후 검사에서 두 집단은 다시 유사하게 수행하였다. 즉, 영유아기에 습득한 출생 언어에 대한 음운적 지식은 수십년 동안 그 지식을 사용하지 않아도 보존될 수 있으며, 그 보존된 지식이 성인이 되어 출생 언어의 음운 대립을 재학습할 때에 도움을 준다는 것을 보여준다.

4 장에서는 지각 영역에서 관찰된 한국 입양인들의 뛰어난 재학습 능력(3 장)이 말소리 산출 영역에서도 관찰되는지 알아보았다. 한국 입양인 집단이 산출한 한국어의 (치경, 양순, 연구개) 경음-평음-격음과 네덜란드인 통제 집단이 산출한 그것을 비교하였다. 실험 참가자들은 첫 번째 지각 훈련을 받고 난 후(사전 검사 조건)와 모든 13 번의 지각 훈련을 받고 난 후(사후 검사 조건) 총 두 차례에 걸쳐 목표 자극을 발화하였다. 한국어를 모국어로 하는 성인 남녀가 음소 식별 과제(phoneme identification task)와 음소 평가 과제(phoneme rating task)를 통해 두 집단의 발음을 평가하였다. 그 결과, 사후 검사 조건에서 한국 입양인 집단의 발음이 통제 집단의 발음에 비하여 더 많은 빈도로 정확하게 식별되었고, 더 좋은 발음으로 평가되었다. 즉, 어린 시절에 습득한 입양인들의 출생 언어에 대한 지식이 말소리 산출 영역에서도 재학습 시에 도움을 줄 수 있다는 것을 보여준다.

5 장에서는 성인기까지 보존된 출생 언어의 음운적 지식이 출생 언어의 음소 재학습에만 도움을 주는지, 아니면 출생 언어의 음소는 아니지만 그와 유사한 음운적 특성을 지닌 새로운 언어의 음소 학습에도 도움을 주는지 알아보았다. 실험 자극으로는 한국어의 경음 대 평음 자음 대립과 음운적으로 일부 유사한 특성을 지닌 일본어의 이중 대 단 자음 대립이 사용되었다. 한국 입양인 집단과 네덜란드인 통제 집단은 일본어의 자음 대립을 식별하는 훈련을 받았고, 사전 검사, 중간 검사,

사후 검사를 통해 그 대립의 식별 능력을 평가 받았다. 그 결과, 세 번의 모든 검사에서 한국 입양인 집단이 통제 집단에 비해 일본어의 이중 자음을 더 잘 식별하였다. 즉, 성인기까지 보존된 한국어에 대한 음운적 지식이 한국어와 유사한 음운적 특성을 지닌 다른 언어의 음소 학습에도 도움을 줄 수 있다는 것을 의미한다.

6 장에서는 한국 입양인 집단과 네덜란드인 통제 집단의 음소 대립 변별(discrimination: 한 쌍의 소리를 듣고 두 소리가 같은지 다른지 선택하는 과제) 능력을 측정하였다. 앞서 사용된 한국어의 (치경, 양순, 연구개) 경음-평음-격음 대립과 일본어의 이중 자음-단 자음 대립을 실험 자극으로 사용하였다. 그 결과, 두 대립 조건 모두에서 입양인 집단과 통제 집단 간의 유의미한 차이가 발견되지 않았다. 이 결과는 앞선 3 장과 5 장에서 관찰된 두 집단 간 차이는 음소 범주를 형성하고 처리하는 과정(식별 과제가 주되게 측정하는 것으로 알려진 과정)에서 주로 일어났을 것임을 시사한다.

본 연구에서는 출생 언어의 경험이 출생 후 단지 몇개월에 한정된 경우에도 그 언어의 소리에 대한 지식이 오래도록 보존될 수 있다는 점을 발견하였다. 생후 5 개월 이전에 입양된 입양인으로만 구성된 한국 입양인 하위 집단과 네덜란드인 통제 집단의 수행을 비교해본 결과, 입양인 하위 집단이 통제 집단보다 한국어의 경음-평음-격음 대립(3 장)과 일본어의 이중 자음-단 자음 대립(5 장) 모두에서 식별 능력이 더 뛰어났다. 생후 5 개월 이전에 입양되었다는 것은 한국어 음운 체계가 완전히 성립되기 이전에 한국어에 대한 경험과 습득이 중단되었다는 것을 의미한다. 그럼에도 불구하고, 수십 년이 지난 성인기에 출생 언어의 음소(혹은 그와 유사한 음운적 특성을 지닌 다른 언어의 음소)를 (재)학습할 때 수행 능력이 통제 집단보다 뛰어났다. 즉, 생후 3 개월에서 5 개월에 불과한 출생 언어의 경험만으로도

성인기까지 보존되는 음운적 지식을 남길 수 있고, 그 지식이 출생 언어의 소리를 성인기이 되어 재학습할 때에 도움을 줄 수 있음을 의미한다.

본 박사 논문은 국제 입양인이 영유아기에 습득한 출생 언어의 소리에 대한 지식이 그 지식을 수십 년 동안 사용하지 않았음에도 불구하고 성인기까지 보존될 수 있음을 밝혔다.

Curriculum Vitae

Jiyoun Choi was born on May 7, 1983, in Seoul, Korea. She studied Psychology at Korea University, Seoul, and received her bachelor's degree in Psychology in 2007. During the first three months of 2007 and of 2008, she worked as an intern in the Language Comprehension Group at the Max Planck Institute for Psycholinguistics in Nijmegen, the Netherlands. In 2009, she received her master's degree in Experimental Psychology at Korea University. In the same year, she worked as a clinical research assistant in the department of neuropsychiatry at Korea University Anam Hospital in Seoul, Korea. In 2010, she was awarded a three-year scholarship from the Max Planck Society to carry out her PhD research at the Max Planck Institute for Psycholinguistics in Nijmegen, the Netherlands. Here she joined the Language Comprehension Group. In 2013, she was awarded a grant from Radboud University Internationalisation Fund and financial support from the Max Planck Institute for Psycholinguistics, which allowed her to spend five months as a visiting scholar at Hanyang University in Seoul, Korea. Currently, she is extending her phonological expertise in the laboratory of Taehong Cho at Hanyang University, Seoul.

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