NATURALISTIC EXPOSURE TO AN UNKNOWN LANGUAGE ALONE DOES NOT LEAD TO ATTUNEMENT TO ITS PHONETIC INVARIANTS

LA EXPOSICIÓN NATURALÍSTICA A UN IDIOMA DESCONOCIDO NO CONDUCE POR SÍ SOLA A LA ADAPTACIÓN A SUS INVARIANTES FONÉTICOS

GEORGIOS P. GEORGIOU
People's Friendship University of Russia (RUDN University) & University of Nicosia (Russia & Cyprus)
georgiou.georgos@hotmail.com

ELENA KKESE
Cyprus University of Technology (Cyprus)
elenakkese@hotmail.com

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ABSTRACT

The present study aims to examine the Cypriot Greek consonant perceptual patterns of Russian speakers who permanently live in Cyprus and do not have experience with Greek, and to determine the effect of naturalistic exposure in an unknown language on speech perception. The experimental group consisted of 16 Russian adult speakers who were living permanently in Cyprus and had no knowledge of Greek, and the control group consisted of 16 Russian adult speakers who were living permanently in Russia, and who did not have knowledge of Greek either. Both populations completed an assimilation test and an AXB discrimination test. The results showed that there were no important differences for the assimilation patterns of both Russian populations, while the discrimination accuracy over Cypriot Greek consonantal contrasts was either similar between the two groups or better for the Russian population living in Russia. Thus, exposure to naturalistic second language stimuli without knowledge of the second language does not contribute to the attunement to phonetic invariants that characterize the second language phones.

Keywords: *Cypriot Greek, Russian, consonant perception, exposure.*

RESUMEN

El presente estudio tiene por objeto examinar los patrones de percepción de las consonantes grecochipriotas por parte de hablantes de ruso que viven permanentemente en Chipre y no tienen experiencia con el griego y, asimismo, determinar el efecto de la exposición naturalista a un idioma desconocido en la percepción del habla. Los sujetos del estudio son 16 adultos rusos que vivían permanentemente en Chipre y no tenían conocimiento de griego, mientras que el grupo de control estaba formado por 16 adultos rusos que vivían permanentemente en Rusia y que no tenían conocimiento de griego. Ambas poblaciones completaron una prueba de asimilación y una prueba de discriminación de tipo AXB. Los resultados muestran que no hay diferencias importantes para los patrones de asimilación de ambas poblaciones rusas, mientras que la precisión de discriminación de los contrastes consonánticos grecochipriotas era similar entre los dos grupos o incluso mejor para la población rusa que vive en Rusia. Por lo tanto, la exposición a un segundo idioma en un contexto naturalistas sin conocimiento del segundo idioma no contribuye a la percepción de los invariantes fonéticos que caracterizan los sonidos del segundo idioma.

Palabras clave: g*recochipriota, ruso, percepción consonante, exposición.*

1. INTRODUCTION

Usually, adults have difficulties in perceiving the phones of a nonnative language due to their heavy reliance on the rules and categories of their first language (L1) (Baker *et al.*, 2008; Iverson *et al.*, 2003; Flege *et al.*, 1999a). Several studies have indicated the influence of L1 perception and the specific difficulties it may cause to the learners of a second language (L2) (e.g., Georgiou, 2018; Evans & Alshangiti, 2018; Tyler *et al.*, 2014). These difficulties are attributed to the fact that specific phones may not contrast in the L1 phoneme repertoires of the learners, making new L2 contrasts difficult to perceive and produce. Examples of contrasts may be the vowels found in 'bet-bat' for Dutch speakers (Boersma, 2005), 'rocket-locket' for Japanese speakers (Aoyama *et al.*, 2004), and 'beat-bit' for Spanish (Flege *et al.*, 1997), Portuguese (Rauber *et al.*, 2005), and Greek speakers (Georgiou, 2019a, 2019c).

Several speech models aim at predicting the perceptual patterns of listeners/learners of a nonnative language. These models differ in their scopes and the claims they make. The *Speech Learning Model* (SLM) was primarily concerned with the ultimate attainment to L2 speech production (Flege, 1995) but at a later stage, it started to show an interest in the ultimate attainment of L2 speech perception (Flege, 2003). This model addresses to fairly experienced L2 learners suggesting that accurate perception of nonnative phones equals to the creation of new L2 phonetic categories. Therefore, if there is great perceived dissimilarity between the L1 and L2 phone, new L2 phonetic categories will likely develop. Nonetheless, new L2 phonetic categories may not be developed in the cases in which a single phonetic category may be used to perceptually process similar L1 and L2 phones. This mechanism of "equivalence classification" (Flege, 1995: 239) may block the development of new categories resulting in overlapped L1-L2 phonetic categories. The reason is because different features or feature weights are used for the development of these categories. Since production seems to correspond to the phonetic properties of L2 representations, effective perception must precede native-like production.

On the other hand, the *Native Language Magnet model* (NLM) (Kuhl, 1994; Kuhl *et al.*, 1992) addresses speech perception in an effort to explain its development from infancy to adulthood. The model was primarily concerned with speech L1 acquisition but it has been extended to address nonnative speech perception (Iverson *et al.*, 2003). According to the NLM, phonetic prototypes act as perceptual magnets that minimise psychological space around them and, as a consequence, phonetic variation is difficult to discriminate around the category prototypes (Kuhl, 1994;

Kuhl *et al.*, 1992). In the cases in which a nonnative phone is too similar to a native prototype, the former will be attracted by the L1 magnet and a new prototype will not be feasible. Therefore, nonnative phones are perceived as better or worse exemplars of L1 prototypes while the development of a new, nonnative category prototype depends on the similarity of the nonnative phone to the native prototypes.

The *Perceptual Assimilation Model* (PAM) (Best, 1994) attempts to account for the performance in perception of diverse nonnative contrasts and it is primarily concerned with nonnative speech perception of naïve learners. PAM is in line with the direct realism (Fowler, 1986; Best, 1984) suggesting that listeners perceive articulatory gestures or the neural commands underlying such gestures. According to the model, nonnative contrasts will be perceived based on their ability to be assimilated into the L1 phonological system. Therefore, PAM distinguishes between perceptual assimilation of single nonnative phones and pairs of contrasting nonnative phones. With reference to single phones, nonnative listeners may assimilate a nonnative phone to "the most articulatorily-similar native phoneme" (Best & Tyler, 2007: 17) due to L1 experience. As a result, a nonnative phone can be categorized as a good, acceptable, or poor instance of an L1 category (categorized), as unlike any L1 phoneme (uncategorized), or as a nonspeech sound (non-assimilated). In relation to pairs of contrasting nonnative phones, six assimilation types have been proposed. The first involves the Two Category assimilation (TC), which implies that the two nonnative phones could be perceived as acceptable instances of two different L1 phonological categories with very good to excellent discrimination. The second refers to the Single Category assimilation (SC), in which the two nonnative phones are perceived both as good or poor instances of the same L1 phoneme and discrimination is predicted to be poor. The third type is the Category-Goodness difference assimilation (CG), which suggests that the two nonnative phones could be perceived as instances of an L1 phoneme but these could differ in that the one nonnative phone is a good exemplar of that L1 phonological category while the other is a bad exemplar of it while discrimination is expected to be moderate to good. All the examples mentioned involve categorization of the nonnative phones to L1 phones. However, there are also cases in which one or both nonnative phones may be uncategorized. Therefore, the fourth assimilation type refers to the Uncategorized-Categorized assimilation (UC), in which one nonnative phone may be perceived as an instance of an L1 phoneme while the other as an uncategorized phone leading to very good discrimination. The fifth type involves the Uncategorized-Uncategorized assimilation (UU) when both phones are uncategorized while discrimination could vary from poor to very good. The Non-Assimilable type (NA) is the last suggested assimilation type in which both nonnative phones are very different from the articulatory properties of L1 phonemes

that are not perceived as speech sounds while discrimination may be poor to very good depending on the similarity of the sounds.

The *Perceptual Assimilation Model of Second Language* (PAM-L2) (Best & Tyler, 2007) constitutes an extension of the PAM to L2 learning. According to the PAM-L2, the perceptual system is shared by all the languages learned and practised by an individual. Therefore, in the cases in which specific L1 phonological categories can lead to the discrimination of L2 contrasts, then the individual does not need to learn these contrasts since the L2 phonemes will be assimilated to the L1 phonological system. Nonetheless, in the cases in which an L1 phonological category cannot lead to the discrimination of L2 contrasts, perceptual learning is needed to "detect the L2 phonological contrast, and to build an L2 vocabulary that preserves a phonological distinction between those phonemes" (Tyler, 2019: 610). Detecting new phonological contrasts in the L2 seems to depend on how the L2 phonemes are initially assimilated to the phonological system of the L1.

The abovementioned models emphasize the importance of L1 experience for L2 perception. Nonetheless, several other external factors are assumed to affect L2 speech acquisition. For example, the age of L2 learning has received much attention in the literature with the majority of the studies to support the existence of one or more critical periods that determine the accurate acquisition of L2 phones (e.g., Hurford, 1991; Long, 1990; Patkowski, 1990; Walsh & Diller, 1981; Scovel, 1969; Lenneberg, 1967). Another important factor which affects the acquisition of L2 speech sounds is the length of residence in the country where the L2 is predominant (Flege *et al.*, 1999b; Flege *et al.*, 1995; Flege & Fletcher, 1992). An effect of length of residence has been found between populations of learners who differed greatly in terms of years of residence in the country where the L2 was spoken. The L1-L2 use is also a significant predictor of L2 phone acquisition. Flege *et al.* (1995) investigated the effect of L1-L2 use on the acquisition of L2 sounds by native Italian immigrants in Canada. The subjects of the study were asked to mention how much they use their L1 or L2 at the work context, in their social life, and at home. The findings indicated that the language use factor reported a significant percentage (15%) of the variance in the L2 accent ratings. Similarly, Flege *et al.* (1997) re-examined the two groups of Italian/English bilinguals who shared an identical (low) age of living in Canada. The first group was using the L1 frequently while the second one was rarely using it. The results provided by the authors showed that bilinguals, who were using their L1 more frequently, had a stronger foreign accent speech than the other bilinguals who were rarely using their L1. In addition, the factor of exposure might be linked with the time that learners spend in the L2-speaking country, the use of the L2 in their daily life, their interaction with native speakers of

the L2, and their exposure with L2 stimuli through the Media and music, among other factors. In general, according to the ecology of language learning, learning a nonnative language in its natural environment (i.e., in the country where is spoken) is more ideal than learning a nonnative language through classroom in a non-naturalistic environment (Best & Tyler, 2007). This is because the learning of a foreign language does not extend much the outside classroom and most of the times the teaching of pronunciation is neglected (Georgiou, 2019b); teachers are L1-accented or speakers come from diverse L2 varieties (Best & Tyler, 2007).

However, all of the above have to do with individuals who actively learn a nonnative language either through naturalistic exposure to the nonnative stimuli or through controlled environments such as classrooms. A crucial point that has not initiated much interest in terms of research is nonnative phone acquisition patterns of individuals who do not have knowledge of the L2 and are not active learners of the L2, but receive significant amount of naturalistic input through their exposure in the nonnative language. Immonen & Peltola (2017) investigated the effects of passive auditory exposure on L2 category perception in younger and older children. The children were involved in behavioral and EEG tests after receiving passive auditory training for two consecutive days. The findings indicated that differences occurred between the perceptual patterns of younger children compared to the older group. Kurkela *et al.* (2019) tested whether passive exposure to unfamiliar speech sounds can result in enhanced discrimination ability in adulthood. The brain response measurements indicated that when listeners were exposed for several consecutive days in the unfamiliar stimuli, they noted better discrimination ability; this was thought to take place only during the infancy period. Krashen (1982) pointed out that the role of input is important for language learning. The author proposes the "input hypothesis" supporting that L2 acquisition is possible even if learners are not able to produce L2 speech sounds. Further evidence for this hypothesis comes from the "silent period" in which children during their first exposure to the L2 may not say a lot since their speaking capabilities are limited. However, they memorise the language and they build competence in the L2 by listening to the L2 speech input around them (Krashen, 1982).

The aim of this study, as a result, is to investigate the Cypriot Greek consonant perceptual patterns of Russian speakers who live in Cyprus, and to determine how the naturalistic exposure of listeners in an unknown language affects speech perception. To this purpose, the Cypriot Greek consonant perceptual patterns of Russian speakers who live in Cyprus will be compared with the perceptual patterns of Russian speakers who live in Russia and do not have substantial knowledge of Cypriot Greek. By examining Cypriot Greek and Contemporary Standard Russian

(henceforth Russian), this study addresses a new set of languages that have received scarce attention in terms of research, that is Russian and Greek. Additionally, even though most of the studies investigate the impact of L2 exposure on speech acquisition by examining people who learn or have knowledge of the target language, this study examines the impact of exposure on speech perception by investigating the perceptual patterns of individuals who neither have knowledge of the nonnative language nor are learners of that language. Specifically, the study intends to show whether two different populations, that is, individuals exposed to L2 stimuli (in the L2-dominant country) and individuals without any exposure to L2 stimuli (in their home country), have differences with respect to their attunement to nonnative phonetic features. For the purpose of this study, the PAM will be used given that it addresses to listeners without knowledge of the target language. Also, it makes testable predictions about the perception of nonnative sounds, which were confirmed by several studies (e.g., Tyler, 2019; Georgiou, 2018; Tyler *et al.*, 2014), and provides a clear picture of the listeners' perceptual patterns. Listeners will be involved in behavioral tests and more specifically in consonant assimilation and discrimination tests on a speech processing software.

2. PHONOLOGICAL SYSTEMS OF RUSSIAN AND GREEK

Russian is an Indo-European East Slavic language that is used as an L1 by about 162 million people and as an L2 by another 110 million worldwide (Lewis, Simons & Fennig, 2013). The written language uses letters from the Cyrillic script, which consists of thirty-three letters. Nonetheless, the phonological system of Russian seems to be more complicated than its orthography. With reference to vowels, Russian has a simple system of five vowels involving /i e a o u/ or even six by including /ɨ/ as a separate phoneme (and not allophone of /i/) (DeArmond, 1975). The consonantal system seems to be rich since most of the consonants have both a palatalized (soft) and a non-palatalized (hard) form, comprising distinct phonemes (Timberlake, 2004); the palatalisation feature has a secondary articulation in Russian. Table 1 indicates that [ʃ ʒ ʦ] have no palatalized equivalents while [ʧʲ ʃː] have no non-palatalized equivalents. Concerning voicing, the language distinguishes between voiced and voiceless consonants. Nonetheless, voiceless consonants cannot be aspirated while these can only occur word-finally (i.e., года [gʌˈd̪aˑ] 'of the year' vs. год [ˈgʷɔˑt] 'year'). Also, [ʃː] is the only long consonant found in Russian. The Russian phonemes are shown in Table 1.

	Bilabial	Labio dental	Dental	Alveolar	Palato alveolar	Pala-tal	Velar
Plosive	p b pʲ bʲ		t d tʲ dʲ				k g kʲ gʲ
Affricate			ʦ	ʧʲ			
Fricative		f v fʲ vʲ		s z sʲ zʲ	ʃ ʒ ʃː		x xʲ
Nasal	m mʲ		n nʲ				
Lateral			l lʲ				
Rhotic				r rʲ			
Glide						j	

Table 1. *Consonantal inventory of Russian (Yanushevskaya & Bunčić, 2015).*

Cypriot Greek belongs to the South-Eastern dialects of Standard Modern Greek (Mackridge, 1985), which is an Indo-European language spoken in Cyprus by approximately 650,000 people (CYSTAT, 2011; Arvaniti, 1999). Cypriot Greek consists of a simple vowel system involving /i e a o u/. Nonetheless, the consonantal system is quite complicated (see Table 2) consisting of consonants that are not used in Standard Greek such as the post-alveolar consonants [ʃ], [ʒ], [ʧ], [ʤ] or consonants that are non-contrastive in Standard Greek such as the palatal consonants [c], [j], [ɲ], [ʎ], and the trill [r] that may occur as allophones in some dialects or idiolects but not as distinct phonemes (Kkese, 2016; Arvaniti, 2010; Kappa, 2002). Another interesting point involves the variability on the articulation of the plosive consonants [t d]. These consonants may vary between dental (Nicolaidis, 1991), dentoalveolar (Nicolaidis, 1994), and alveolar (Nicolaidis, 2001, 2000) depending on each Greek speaker and the phonetic environment, specifically on the vowel that follows. The dialect also employs geminates that are treated as separate phonemes (in most descriptions) and non-contrastive (allophonic) segments (shown in italics in Table 2). Voicing is used contrastively since plosive consonants can be voiceless aspirated or unaspirated (Kkese & Petinou, 2017; Kkese, 2016). Voiced plosives are not present or are realized differently in Cypriot Greek (Kkese & Petinou, 2017; Kkese, 2016; Okalidou *et al.*, 2010; Botinis *et al.*, 2004). Table 2 illustrates the consonantal phones found in Cypriot Greek.

	Labial	Dental	Alveolar	Post alveolar	Palatal	Velar
Plosive	p pʰ: *b*	t tʰ: *d*			c cʰ: *ɟ*	k kʰ: *g*
Affricate			ts	ʧ ʧ: *ʤ*		
Fricative	f f: v *v:*	θ θ: ð *ð:*	s s: z *z:*	ʃ ʃ: ʒ *ʒ:*	ç ç: ʝ *ʝ:*	x x: ɣ *ɣ:*
Nasal	m m:	n n:			*ɲ*	*ŋ*
Lateral			l l:		*ʎ*	
Tap			ɾ			
Trill			r			

Table 2. *Consonantal inventory of Cypriot Greek (Arvaniti, 2010).*

3. PAM AND RELATION BETWEEN NONNATIVE PHONES AND L1 CATEGORIES

PAM bases its predictions on the connection between nonnative phones and L1 phonological categories. This connection is often examined in perceptual assimilation experiments in which listeners of a nonnative language, who have no or minimal knowledge of the target language, are called to identify nonnative phones in terms of L1 categories and then rate the goodness-of-fit of those phones to L1 categories. This study examines how Cypriot Greek consonants are assimilated to the listeners' L1 phonological categories and the discrimination of Cypriot Greek consonantal contrasts. The Cypriot Greek consonants examined are [t d ɟ g θ ð ç x] (see Table 3).

Consonants	Cypriot Greek	Russian
[t]	voiceless dental plosive	voiceless dental plosive
[d]	voiced dental plosive	voiced dental plosive
[ɟ]	voiced palatal plosive	---
[g]	voiced velar plosive	voiced velar plosive
[ð]	voiced dental fricative	---
[θ]	voiceless dental fricative	---
[ç]	voiceless palatal fricative	---
[x]	voiceless velar fricative	voiceless velar fricative

Table 3. *Examined consonants in Cypriot Greek and Russian.*

Specifically, the consonants under investigation are the Cypriot Greek voiceless and voiced dental plosives [t d], the voiced and voiceless dental fricatives [ð θ], the voiced palatal plosive [ɟ], the voiced velar plosive [g] as well as the voiceless palatal fricative [ç], and the voiceless velar fricative [x]. The consonants [t d g x] are

expected to be perceived as equivalents to the close Russian phonological categories [t d g x] respectively since these sounds share the same manner and place of articulation and have the same voicing in both languages. However, the Cypriot Greek consonants [ð θ ɟ ç] are absent from the Russian phonological system and might be perceived as instances of a range of L1 phonological categories by the listeners. Specifically, the Cypriot Greek [ð] might be perceived as instance of the Russian [d] since they share two characteristics [+voiced] [+dental], or even the Russian [z] due to common features [+voiced] [+fricative]. The Cypriot Greek [θ] might be perceived as instance of the Russian [t] since these sounds in both languages have the common features [-voiced] [+dental], or even as an instance of the Russian [s] [-voiced] [+fricative]. Also, the Cypriot Greek palatals [ɟ] and [ç] (which are allophones of the Cypriot Greek phonemes /g/ and /x/) might be perceived as instances of the palatalized [g^{j}] and [x^{j}] respectively, which are phonetically close to them. [+voiced] [+plosive] and [-voiced] [+fricative] respectively. In terms of PAM, an SC assimilation is expected for the Cypriot Greek contrasts [θ]-[t] and [ð]-[d] with poor discrimination accuracy. However, we do not rule out a TC assimilation with excellent discrimination accuracy, if the first member of the contrasts would be assimilated to different L1 phonological categories. With respect to the Cypriot Greek contrasts [ɟ]-[g] and [ç]-[x], we expect a TC assimilation in case that the contrast members are perceived as exemplars of two different Russian phonological categories but we cannot exclude a possible CG assimilation with fair-to-good discrimination since some phonetic details between the contrast members might be perceived. Finally, UC assimilations for all contrasts are also possible because listeners may assimilate consonants that are not present in their native language to various L1 phonological categories. Thus, concrete predictions cannot be formed since the assimilation of these phones to L1 categories might vary.

As a consequence, the study seems to be the first to test the predictions of the PAM model for the perception of a set of Cypriot Greek initial and final consonants by Russian listeners who live in Cyprus and have no knowledge of Greek. First, it examines the assimilation of specific Cypriot Greek consonants to Russian phonological categories. Second, it investigates the discrimination of specific pairs of Cypriot Greek consonantal contrasts by Russian listeners. Finally, the speech perceptual patterns of Russian speakers in Cyprus will be compared with those of Russian speakers who live in Russia. The difference between the two populations is that the former has naturalistic exposure to the target language while the latter does not have any exposure; however, both populations do not know Greek at all. We expect a positive effect of exposure to the target language input on the speech perception patterns of the speakers. Specifically, Russians living in Cyprus will be

able to discriminate more accurately the Cypriot Greek phonetic contrasts than Russians living in Russia. Yet, we cannot predict the exact degree of difference between the two populations of speakers with respect to the discrimination accuracy of Cypriot Greek contrasts.

4. METHODOLOGY

4.1 Participants

Thirty-two Russian speakers participated in the study forming the experimental and the control group. Before taking part into the tests, all individuals completed a questionnaire in order to gather information about their linguistic and sociolinguistic background. The experimental group consisted of 16 speakers (5 males, 11 females) who were students at the University of Central Lancashire, Cyprus and had an age range of 17-28 years. (M_{age}= 19.44 years). Participants were carefully selected in order to match for their linguistic and sociolinguistic characteristics. Specifically, they were Russian middle-class students of various fields (e.g., marketing, business administration), who were living permanently in Cyprus for a time period of three months to three years. Specifically, three participants reported living in Cyprus for three months, five participants for one year, two participants for two years, and two participants for three years. Four of the participants provided no response but given that all participants arrived in Cyprus to attend the specific university, it implies that three years could be the maximum amount of years staying in Cyprus. Although they reported that they know only a small number of Greek words, they did not have any knowledge of Greek and they never received formal instruction in Greek. Also, they mentioned that they do not try to use Greek in their daily conversations (e.g., supermarket, shops, etc.) and they were communicating with their parents in their mother tongue, while at the University they were using English. All of them were interacting with Cypriot Greek speakers using English as lingua franca, considering that the latter language is widely-used on the island (Kkese & Lokhtina, 2017). Participants had some exposure in Greek. Specifically, they mentioned that sometimes they watch TV programs in Greek, they listen to Greek music, and they usually listen to their Greek Cypriot friends speaking with each other in Greek.

The control group of the study was the same as in Georgiou *et al.* (2020). It consisted of 16 speakers (14 females and 2 males) who were residing permanently in Russia. These speakers were all students at RUDN University, Moscow aged 19-26 (M_{age}= 21.25 years) living in Moscow or other parts of Russia, and originated from moderate-income families. The speakers of the control group had no knowledge of Greek and had only basic knowledge of English and other languages. All of the

participants reported that they never faced any language or hearing disorder. We ensured that inter-group differences were eliminated since both groups had similar linguistic and sociolinguistic characteristics except the country of residence.

4.2 Stimuli

The stimuli were taken from Georgiou *et al.* (2020). The Greek stimuli for both the assimilation and discrimination tests consisted of the following eight Greek consonants: [θ t ð d ɟ g ç x] embedded in nonsense Greek syllables in the frame of [Ca] and [aC] (C=consonant) (e.g., [θa], [aθ], [ta], [at]). Two adult Cypriot Greek native speakers (one male and one female) who did not have any knowledge of Russian, produced the stimuli at a normal speaking rate and they were recorded at a 44.1 kHz sample. These stimuli were provided to the experimental group. With respect to the recordings of the stimuli that were provided to the control speakers, the male Greek speaker was the same used in the experimental group recordings.

4.3 Procedure

The same procedure as in Georgiou *et al.* (2020) was also followed in this study. The assimilation and the discrimination tests were carried out in a sound-attenuated room at RUDN University, Moscow for Russian speakers who live permanently in Russia and at University of Central Lancashire in Larnaca, Cyprus for Russian speakers who live permanently in Cyprus. The assimilation test was created and modified in Praat (Boersma & Weenink, 2018). Participants were listening through a set of headphones connected to a PC to the Greek consonants (with a listening volume at 75dB) and they were instructed to match these consonants with the most similar L1 sound by clicking on one of options provided by the script. Then, they had to rate how good exemplar the Greek consonant was to the Russian category that they chose, by clicking on a 1-5 Likert-point scale (1=very poor, 5=very good). For practical reasons, only 22 Russian consonants were presented in the script. A small pilot study involving two Russian speakers before the experiment indicated that the Greek consonants were assimilated only to some Russian consonant categories and, therefore, the categories that received no assimilations were excluded from the script. The following 22 Russian consonants were presented in the script: б бь, в вь, г ги, д дь, з зь, к ки, п пь, с сь, т ть, ф фь, х хи. Each participant assimilated a total of 48 items (8 consonants × 2 positions × 3 repetitions). The intertribal interval was 1s and they had 5s to choose their response and rate it. Participants could have a five-minute break at the midpoint. After the assimilation test, participants completed an AXB discrimination test, which was set in Praat. This test would examine the ability of participants to discriminate four

Greek consonantal pairs: 1) [θ]-[t], 2) [ð]-[d], 3) [ɟ]-[g], and 4) [ç]-[x]. Each consonantal pair appeared in four possible configurations: AAB, ABB, BBA, BAA; where A and B represent different Greek syllables having different consonants. Participants were listening through the headphones (listening volume was set at 75dB) to a triad of Greek syllables and they had to choose whether the first word was the same as the first or the third by clicking on the label "first" or "third" on the script. Listeners had to discriminate a total of 96 items (4 contrasts × 4 configurations × 2 positions × 3 repetitions). After the 32nd and the 64th triad, participants could have a five-minute break. The inter-stimulus interval was set at 2s and the inter-trial at 5s. No feedback was provided in both tests, while the target stimuli were not repeated.

5. RESULTS

5.1. Assimilation test

Table 4 and Table 5 present the assimilation of Cypriot Greek (CY) consonants to the Russian (RU) phonological categories by Russian speakers who live in Russia (Georgiou *et al.*, 2020) and Cyprus respectively. For practical reasons, the tables show only the phonological categories with the highest percentages of assimilations for each sound. "PER." shows the percentage of the responses to that phonological category. "C/U" indicates whether the consonant was categorized or uncategorized; we adopted a lenient categorization threshold set at 50% of the selected responses. "GFR" shows the consonants goodness of fit ratings.

CV syllable				VC syllable			
CY → RU	PER.	C/U	GFR	CY → RU	PER.	C/U	GFR
[θ] → [f]	50	C	3.1	[θ] → [s]	44	U	2.9
[t] → [t]	67	C	3.3	[t] → [t]	100	C	3.6
[ð] → [z]	50	C	3.2	[ð] → [z]	65	C	3.2
[d] → [d]	98	C	3.5	[d] → [d]	60	C	2.9
[ɟ] → [g^{j}]	27	U	2.3	[ɟ] → [g^{j}]	42	U	2.7
[g] → [g]	94	C	3.2	[g] → [k]	52	C	3
[ç] → [x^{j}]	54	C	3.1	[ç] → [x^{j}]	65	C	3.1
[x] → [x]	96	C	4.2	[x] → [x]	56	C	3

Table 4. *Assimilation of the Cypriot Greek (CY) consonants to the Russian (RU) phonological categories by Russian speakers who live in Russia.*

CV syllable				VC syllable			
CY → RU	PER.	C/U	GFR	CY → RU	PER.	C/U	GFR
[θ] → [f]	67	C	4.2	[θ] → [s]	50	C	3.5
[t] → [t]	88	C	3.9	[t] → [t]	81	C	3.6
[ð] → [v]	35	U	4.2	[ð] → [v]	44	U	3.4
[d] → [d]	88	C	4.1	[d] → [d]	85	C	3.1
[ɟ] → [g]	50	C	3	[ɟ] → [g^{j}]	77	C	3.9
[g] → [g]	63	C	3.8	[g] → [g]	96	C	3.3
[ç] → [x]	44	U	3.4	[ç] → [x^{j}]	56	C	3.2
[x] → [x]	100	C	4.6	[x] → [x]	90	C	3.7

Table 5. *Assimilation of the Cypriot Greek (CY) consonants to the Russian (RU) phonological categories by Russian speakers who live in Cyprus (Georgiou et al., 2020).*

On the basis of PAM predictions, the Cypriot Greek [θ]-[t] CV contrast of Russian speakers in Cyprus resulted in a TC assimilation, the [ð]-[d] and the [ç]-[x] resulted in a UC assimilation, while the [ɟ]-[g] would be either an SC or a CG assimilation. To determine their exact assimilation type, a paired sample t-test was run between their goodness-of-fit ratings. The results showed that there was a significance difference between their goodness-of-fit ratings; hence, a CG assimilation type occurred [$t(15) = 3.2$, $p<0.05$]. With respect to the VC Cypriot Greek contrasts, the [θ]-[t], [ɟ]-[g], and the [ç]-[x] resulted in a TC assimilation, while the [ð]-[d] signalled a UC assimilation.

The assimilation patterns of both populations of Russian speakers had both convergences and divergences. The commonplace in their patterns is that they assimilated the Cypriot Greek consonants [θ t d g x] to the corresponding Russian categories [f t d g x] in CV syllables, and the Cypriot Greek consonants [t d ç x] to the corresponding Russian categories [t d x^{j} x] in VC syllables. Nevertheless, in CV syllables, the Cypriot Greek [ð] and [ç] were considered as categorized exemplars by the Russians in Russia, while Russians in Cyprus perceived them as uncategorized consonants, and the Cypriot Greek [ɟ] was uncategorized for Russians in Russia, but it was categorized into an L1 category by Russians in Cyprus. Also, in regard to the VC syllables, the Cypriot Greek [θ] and [ɟ] were perceived as uncategorized exemplars by Russians in Russia, but as categorized exemplars by Russians in Cyprus. Finally, the Cypriot Greek [ð] was categorized for Russians in Russia but it was perceived as uncategorized for Russians in Cyprus, while the Cypriot Greek [g] was categorized to a different L1 category for the two populations.

5.2. Discrimination test

Table 6 shows the discrimination accuracy of four Cypriot Greek consonantal contrasts as discriminated by Russian speakers who live in Russia (Georgiou *et al.*, 2020) and in Cyprus respectively.

	Russian speakers in Russia				Russian speakers in Cyprus			
	CV syllable		VC syllable		CV syllable		VC syllable	
Contrast	Correct	SD	Correct	SD	Correct	SD	Correct	SD
[θ]-[t]	91	24.7	84	23.9	85	25.2	82	28.2
[ð]-[d]	95	18.7	92	24.8	87	33.9	88	28.5
[ɟ]-[g]	89	24.3	87	14.5	83	35.1	75	38.6
[ç]-[x]	94	16.7	93	24.9	82	32.2	81	29

Table 6. *Percentages of correct responses and standard deviations (SD) in regard to the discrimination of Greek consonantal contrasts in both CV and VC context by the Russian speakers who live in Russia (Georgiou et al., 2020) and in Cyprus respectively.*

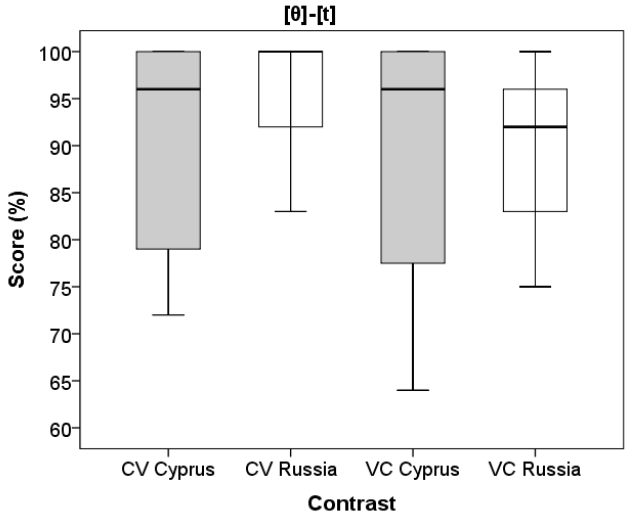

Figure 1. *Boxplot for the discrimination of the Cypriot Greek [θ]-[t] contrast by Russians in Cyprus and Russians in Russia*.

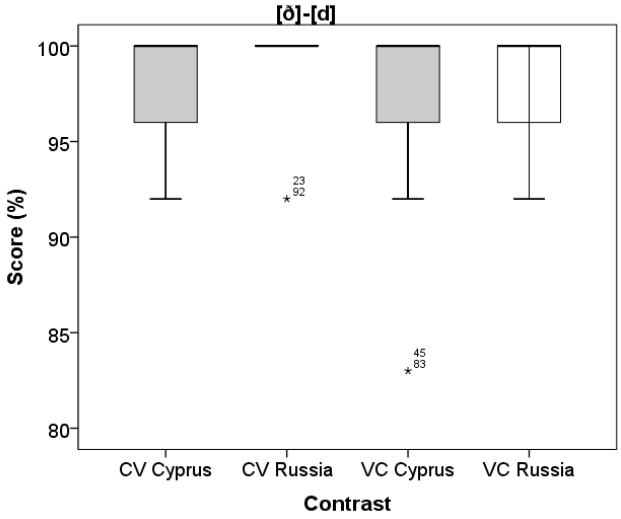

Figure 2. *Boxplot for the discrimination of the Cypriot* Greek [ð]-[d] *contrast by Russians in Cyprus and Russians in Russia.*

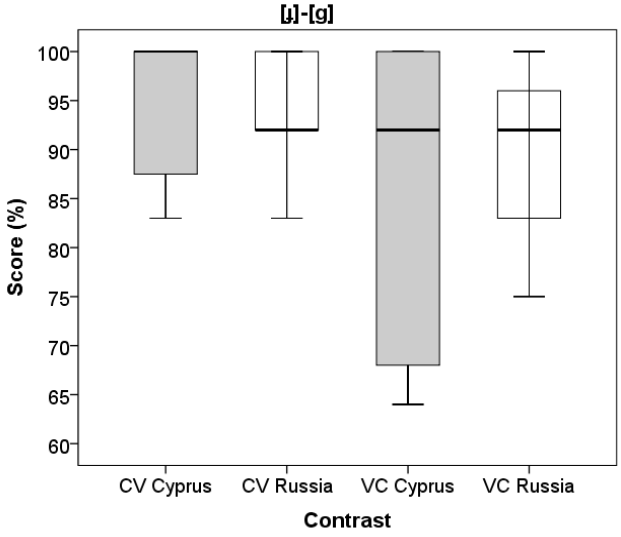

Figure 3. *Boxplot for the discrimination of the Cypriot Greek [ɟ]-[g] contrast by Russians in Cyprus and Russians in Russia.*

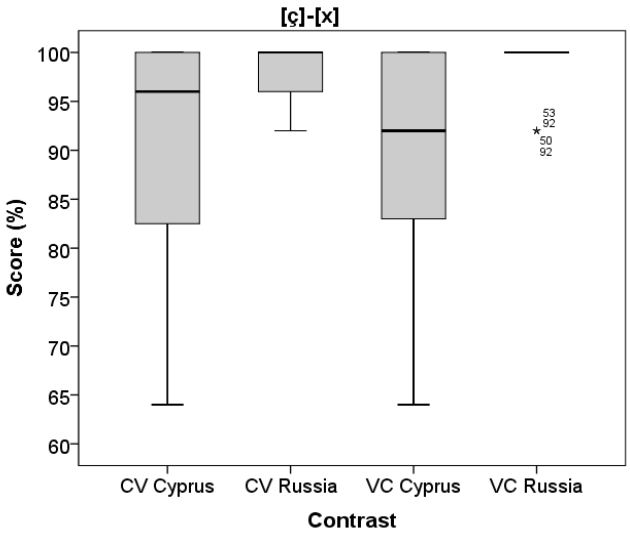

Figure 4. *Boxplot for the discrimination of the Cypriot Greek [ç]-[x] contrast by Russians in Cyprus and Russians in Russia.*

A 4×2×2 *mixed repeated measures ANOVA* was run in R (R Core Team, 2013) to determine the effect of *Contrast, Contrast Type*, and *Population* on the discrimination *Score*. *Contrast* (4 levels: 4 consonantal contrasts), and *Contrast Type* (two levels: CV and VC) were the within-subjects factors, while *Population* (2 levels: Russians in Cyprus, Russians in Russia) was the between-subjects factor. *Score* was the dependent variable (percentage of correct responses). The results showed that there was a significant effect of *Population* [$F(1,30) = 13.3$, $p<0.05$] and *Contrast* [$F(3,90) = 19.5$, $p<0.05$] on *Score*, but a non-significant effect of *Contrast Type* [$F(1,30) = 5.7$, $p<0.05$]. Also, the interaction of *Contrast* × *Contrast Type* [$F(3,90) = 15.2$, $p<0.05$], *Contrast* × *Population* [$F(3,90) = 18.9$, $p<0.05$] was significant, but a non-significant effect of *Population* × *Contrast Type* interaction was found [$F(1,30) = 5.2$, $p>0.05$].

To understand the *Contrast* × *Population* interaction, we used *independent t-tests* to investigate differences in between the two populations. With respect to the CV syllables, significant differences were observed for the discrimination of [ð]-[d] [$t(30) = 2.7$, $p<0.05$] and the [ç]-[x] contrast [$t(30)=3.4$, $p<0.05$], indicating that Russians in Russia could better discriminate those contrasts (M =95%, M=94%) than Russians in Cyprus (M=87%, M=82%). For the VC syllables, significant differences

were found for the [ɟ]-[g] [t(30) = 2.3, p<0.05] and the [ç]-[x] [t(30)= 3.9, p<0.05] contrasts, signaling that Russians in Russia could discriminate them more accurately (M=87%, M=93%) compared to Russians in Cyprus (M=75%, M=81%).

6. DISCUSSION

The present study aimed at investigating the Greek consonant perceptual patterns of Russian listeners who live in Cyprus and do not have experience with Greek. Also, it aimed at examining the impact of naturalistic exposure in an unknown language on the perception of the nonnative sounds by comparing Russian listeners who live in Russia and Russian listeners who live in Cyprus; both populations did not speak Greek.

The effect of the listeners' L1 was evident in the categorization of the nonnative consonants into their L1 phonological system. Cypriot Greek consonants that had the same manner and place of articulation with Russian consonants were assimilated to those Russian counterparts. Difficulties occurred with consonants that are absent from the Russian phonological system. These consonants were either categorized into similar to their L1 phonological categories or remained uncategorized. One important finding is that Cypriot Greek palatals in VC syllables were perceived as instances of the palatalized Russian consonants. Surprisingly, the assimilation scores of most Cypriot Greek palatals that were assimilated to Russian palatalized velars (e.g., Greek [ç] to Russian [x^{j}]) were not high considering that they are not actually palatalized but palatal consonants with one constriction (prepalatal area) since the back of the tongue cannot bend to create two constrictions; one against the soft palate and another in the prepalatal area. This might be explained due to acoustic differences between Cypriot Greek palatals and Russian palatalized velars. The Cypriot Greek [ɟ] and [ç] can be described as true palatals, while the Russian palatalized velars [k^{j} g^{j} x^{j}] have a front point of constriction and are realized as post-palatals (Keating & Lahiri, 1993).

The results of the assimilation test indicated that both populations of Russian speakers had similar and different patterns with respect to the assimilation of Cypriot Greek consonants to their L1 phonological system. The similarities were found mostly in the assimilation of consonants that are present both in Cypriot Greek and Russian phonological systems. This finding was expected since some consonants in Cypriot Greek and Russian share very similar acoustic features. The differences were fewer than the similarities, and were observed in consonants that are not present in the Russian phonological system. However, the most notable difference was the perception of the Cypriot Greek [ð], which although it was not assigned to

any L1 phonological category by Russians living in Cyprus, it was mainly recognized as [v]. Nonetheless for Russians living in Russia, it was perceived as an instance of [z]. Surprisingly, the Cypriot Greek [θ] was perceived by both Russian populations mostly as an instance of the Russian [f] in CV syllables and an instance of the Russian [s] in VC syllables. Therefore, no dramatic differences were observed in the assimilation of Cypriot Greek consonants between Russians who live in Cyprus and Russians who live in Russia.

The findings of the AXB test showed that the discrimination of Cypriot Greek consonantal contrasts by Russian speakers who live in Cyprus ranged from good to very good. There were some differences in the discrimination scores in comparison to the other Russian group, yielding that Russian speakers in Cyprus could discriminate Cypriot Greek consonantal contrasts either in a similar manner to the Russian speakers in Russia or with less accuracy. In any case, the results did not show any advantage of Russian speakers who live in Cyprus over Russian speakers who live in Russia with respect to the discrimination of segmental contrasts.

According to the results of the assimilation and the discrimination tests, it is concluded that Russian speakers who are exposed to Cypriot Greek naturalistic input cannot discriminate better the Cypriot Greek consonantal contrasts than Russian speakers who live in Russia. Recall that none of the populations has experience with Greek, nevertheless, Russians who live in Cyprus receive Cypriot Greek input since the latter variety is widely spoken in the island. Therefore, naturalistic exposure to the nonnative language input may not be enough to make listeners attune to the acoustic invariants of the phones of the latter language. This attunement can be achieved with the expansion of the listeners' vocabulary (Antoniou *et al.*, 2012), and hence, it requires the learning of the language and not just listening to the L2 input. The results of this study seem to diverge from results of previous studies that suggest a positive effect of passive auditory exposure on L2 category perception (e.g., Kurkela *et al.*, 2019; Immonen & Peltola, 2017). However, these studies have involved inexperienced listeners into phonetic training sessions, which were fruitful for their discrimination performance.

The results of the study can also be offered for the evaluation of PAM predictions. The assimilations in the CV context, that is, TC, UC, and CG, did not differ with each other in terms of discrimination scores. In the VC context only one TC type differed with another TC and a UC type. These findings seem to partially disagree with the main assumptions of PAM, which supports a TC > CG relationship. With respect to the UC type, its discrimination accuracy may vary. Recent studies (e.g., Faris *et al.*, 2016, 2018) showed that the degree of overlap of the uncategorized

phone (overlapping, partially overlapping, and non-overlapping) with the other above-chance assimilated phones determines the discrimination accuracy of the UC type as well as its relationship with the other assimilation types. We assume that PAM's predictions will be moved to a different direction in the near future since category overlapping offers more precise predictions about the discrimination accuracy of the nonnative phones. Also, the consonant position played an important role for the perception of the words since different assimilation types emerged in CV vs. VC syllables. Therefore, consonantal context has to be taken into consideration when forming predictions about the assimilation of nonnative phones to the L1 phonological system and discrimination of these phones.

Finally, we assume that listeners living in a country where the L2 is dominant do not necessarily distinguish better phonetic differences if compared to listeners without any exposure (and knowledge) in that language. For reasons that cannot be explained in this study, learners without any exposure or knowledge of the L2 had better discrimination performance for some contrasts than learners with exposure and no knowledge of the L2. We are aware that they might be other factors that define the perception of nonnative consonants, and which were not taken into consideration in this study, such as the speakers' cognitive functions, proficiency in other foreign languages, individual talents, and other.

ETHICAL STATEMENT: The study received approval by the University of Central Lancashire, Cyprus as well as the Cyprus National Bioethics Committee [ΕΕΒΚ ΕΠ 2019.01.183] due to the involvement of human participants in the experiments. All participants gave their written consent for their participation to the experiments according to the declaration of Helsinki.

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