

**CUE-RELIANCE AND
VOWEL PERCEPTUAL PATTERNS
OF CYPRIOT GREEK CHILDREN
WHO LEARN ENGLISH**

**PONDERACIÓN DE RASGOS
Y PATRONES PERCEPTIVOS
DE LAS VOCALES INGLESAS EN NIÑOS
GRECOCHIPRIOTAS QUE APRENDEN INGLÉS**

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Artículo recibido el día: 13/06/2019

Artículo aceptado definitivamente el día: 04/11/2019

Estudios de Fonética Experimental, ISSN 1575-5533, XXVIII, pp. 229-253

ABSTRACT

The aim of the present study is to investigate the vowel perceptual patterns of Cypriot Greek children who learn English as a foreign language in Cyprus and their cue-reliance during L2 vowel categorization. To this purpose, 26 native speakers of Cypriot Greek participated in a perceptual assimilation task and an AXB discrimination task. The findings showed that learners assimilated two or more English vowels to a single phonological category of their native language. Furthermore, their discrimination over selected English vowel contrasts ranged from poor to moderate. The small L1 vowel inventory of learners resulted in multiple assimilations of L2 vowels to the same L1 phonological category and the lack of linguistic experience prevented the establishment of novel phonological categories. In addition, the temporal cues of L2 vowels were not employed for their better fitting to the already assimilated L1 phonological categories. The predictions were in general consistent with the assumptions of the Perceptual Assimilation Model-L2.

Keywords: *Cypriot Greek, English, children, perception*

RESUMEN

El objetivo del presente estudio es investigar los patrones de percepción vocal de los niños grecochipriotas que aprenden inglés como lengua extranjera en Chipre y su ponderación de la señal durante la categorización de las vocales de la L2. Para este propósito, 26 hablantes nativos de griego chipriota participaron en experimentos de asimilación y discriminación de tipo AXB. Los resultados mostraron que los aprendices asimilaron dos o más vocales inglesas a una sola categoría fonológica de su idioma nativo. Además, su discriminación sobre los contrastes de las vocales inglesas seleccionadas varió de pobre a moderada. El pequeño inventario de vocales de la L1 de los aprendices dio lugar a múltiples asimilaciones de vocales de la L2 a la misma categoría fonológica de la L1 y la falta de experiencia lingüística impidió el establecimiento de nuevas categorías fonológicas. Es más, las señales temporales de las vocales de la L2 no se emplearon para su mejor ajuste en las categorías fonológicas de la L1 ya asimiladas. En general, las predicciones fueron consistentes con las suposiciones del Perceptual Assimilation Model-L2.

Palabras clave: *chipriota griega, inglés, niños, percepción*

1. INTRODUCTION

It is well documented by the literature that infants are able to discriminate nonnative sound contrasts in most languages until the first six months of their life (Georgiou, 2018a; Kuhl *et al.*, 2006; Werker and Tees, 1984). This ability is gradually lost at a later stage with the development of the first language (L1) phonological system, which creates speech perception difficulties since learners filter every second language (L2) sound through their L1 phonological system (Bosch *et al.*, 2000; Sebastián-Gallés and Soto-Faraco, 1999; Bongaerts *et al.*, 1997; Best and Strange, 1992; Flege and Eefting, 1987). In other words, they move from a universal acoustic discrimination to wrapped language-specific perception (Kuhl, 2000). Therefore, learners with different L1s have different perceptual difficulties. For instance, the German vowel contrast /e/-/æ/ is discriminated differently by Spanish and French learners of German (Flege *et al.*, 1997). Spanish speakers are able to discriminate the aforementioned German vowel contrast very well since they perceive the two vowels as being exemplars of two different phonological categories of their L1 while French speakers perceive these vowels as being instances of a single French phonological category. Also, phonological inventory size matters since speakers with small inventories tend to assimilate nonnative sounds that come from larger sound inventories to a single phonological category of their L1 (Georgiou, 2019a; Lengeris, 2009; Frieda and Nozawa, 2007; Hacquard *et al.*, 2007; Fox *et al.*, 1995). For instance, Kartushina and Frauenfelder (2013) reported that Spanish learners of French did not manage to discriminate accurately the French /e/-/ɛ/ vowel contrast since these vowels were perceived as being similar since Spanish has only the sound /e/ and not /ɛ/.

The Native Language Magnet (NLM) model was proposed by Kuhl (1992) aims at investigating speech perception by taking into consideration cognitive aspects. Specifically, it argues that phonetic representations of speakers' L1 categories, which are called "prototypes", are developed by infants during the first year of their life (Kuhl, 1992; Kuhl and Iverson, 1995). These prototypes are good instances of categories and work as "magnets" for other sounds of that categories. NLM makes as well predictions for L2 learning by adults. It predicts that a learner might face difficulties in discriminating an L2 sound that is phonetically similar to an L1 prototype while L2 sounds that are dissimilar to any L1 prototype are predicted to be discriminated more easily. The Second Language Linguistic Perception Model (L2LP) was developed by Escudero (2005, 2009) supporting that the initial learning of L2 acquisition is the result of L1 acquisition since similarities or differences between the L1-L2 phonemes shape the perception of the L2 phonemes. The model is based on three scenarios: (a) "new scenario",

which indicates that two L2 phones have been included to the same L1 category and therefore learners must split their L1 category or create new phonological categories, (b) “similar scenario” in which two L2 contrasts are acoustically close to two different L1 categories; this scenario is less problematic than creating new categories according to the L2LP, and (c) “subset scenario”, which indicates that a single L2 sound was perceived as more than one category; this scenario creates less difficulties for the learners than the “new scenario” since learners do not have to create new categories (van-Leussen and Escudero, 2015). The Automatic Selective Perception (ASP) Model (Strange, 2011) suggests that there is not only a single way of perceiving speech, but different acts of perception that adapt to the purpose of communication. Thus, according to the ASP, evaluation tasks are generally carried out taking into account a mode of phonetic perception, which requires more attention and more cognitive effort. On the other hand, in order to recognize the forms of words, the phonological mode is used, since speakers ignore phonetic variations such as speech speed, prosodic structure, or minor dialectal variations.

The Speech Learning Model (SLM) (Flege, 1995) is a perceptual and production model that deals with experienced learners of an L2 (that is, learners who live in an L2-dominant country). It supports that there is a common phonological space for the L1 and the L2 and that learners form phonological categories from speech input. If an L1 sound is perceived to be similar with an L2 sound, then merged categories will be formed and the perception and production of that L2 sound will be inaccurate. The acquisition of similarity between an L1 and an L2 phone is fostered by the mechanism of equivalence classification. The SLM considers the effect of several sociolinguistic factors on the perception and production of L2 sounds such as age of arrival in the L2-speaking country, age that someone started to learn the L2, L1/L2 use and many others. However, the model does not form detailed predictions about the perception of speech sounds. Also, the consideration of time of learning (e.g., early stage) is important in order to make accurate predictions about the L2 learners’ speech acquisition patterns (Georgiou, 2018b).

The Perceptual Assimilation Model (PAM) (Best, 1995) is one of the most influential speech models that investigates the sound perceptual patterns of monolingual listeners with respect to languages that they do not have experience with. PAM’s framework is based on a direct realism theory where speech signal is directly picked by the listeners without any process of the acoustical information (Best, 1995). PAM contends that nonnative sounds might be assimilated to similar L1 sounds due to the effect of the speakers’ L1 (Bundgaard-Nielsen *et al.*, 2011), however, perception of within-category L1-L2 differences might be possible if

listeners are able to perceive much gestural dissimilarities between the L1 and the L2 sounds (Tyler *et al.* 2014; Antoniou, 2010). In order to explain better the perceptual mechanisms, PAM proposed six types of assimilation for nonnative sounds to the listeners' L1 phonological system; these assimilation types also define the degree of discrimination of pairs of nonnative sound contrasts (Best and Tyler, 2007). In the Two Category (TC) Assimilation, two nonnative speech sounds are assimilated to two different L1 categories and, thus, the discrimination of this contrast is predicted to be excellent. The Single Category (SC) Assimilation signals that a nonnative contrastive sound contrast differs from an ideal L1 sound and, therefore, the discrimination of its members will be poor. In the Category Goodness (CG) Assimilation type two nonnative sounds are assimilated to the same L1 phonological category but one of them constitutes a good exemplar of that L1 sound while the other constitutes a bad exemplar of it; discrimination is predicted to be moderate to good. The Uncategorized-Categorized (UC) Assimilation implies that one nonnative sound is assimilated to an L1 category while the other falls into the phonological space without being assimilated to any L1 phonological category. In this case, it is expected a very good discrimination of the nonnative sounds. In the Uncategorized-Uncategorized (UU) both nonnative sounds fall into the phonological space; discrimination of these members is predicted to be poor to very good. Finally, the Non-Assimilable (NA) type signals that neither of the two nonnative sounds is perceived as a speech sound and discrimination might be poor to excellent. PAM-L2 (Best and Tyler, 2007) is the extended version of PAM and deals with the perceptual patterns of L2 learners (instead of novice learners that PAM deals with). PAM-L2 argues that L2 phonological categories might be assimilated to existing L1 phonological categories but if an L2 sound is perceived as dissimilar from any L1 sound, then novel phonological categories might be developed. Also, PAM-L2 supports that the expansion of vocabulary is associated with the discrimination of more phonetic distinctions on the basis of lexically relevant categorical differences in the L2 (Antoniou *et al.*, 2012).

The purpose of SLM, PAM, and PAM-L2 is similar: to predict the ability of learners/listeners in the perception of L2/unfamiliar contrasts. However, SLM is mainly a production model despite the fact that it makes some general predictions about the reorganization of speech sounds after perceiving L2 speech input. Both PAM and PAM-L2 make explicit perceptual predictions, however, PAM's predictions are based on inexperienced learners while PAM-L2 focuses on learners with experience in the L2. So, for developing hypotheses in this study, PAM-L2 was chosen since the learners of the study have some experience with English. Several studies in the literature have tested the predictions of PAM-L2. Georgiou

(2018) investigated the discrimination of L2 Greek vowel contrasts by Arabic speakers. The results showed that contrasts that signalled a CG assimilation were more distinguishable than contrasts of SC assimilation type. The same relationship of assimilation types as reported in Georgiou (2018) was also reported in Mahmoud (2013) who investigated the perception of Arabic contrasts by American English learners of Arabic. By contrast, Sun and van Heuven (2007) studied the perception of English vowel contrasts by Chinese listeners concluding that the CG assimilation was less discriminable than the SC assimilation type. Thus, the predictions of PAM-L2 were not confirmed by this study.

An important issue in speech perception studies is the cue-reliance of L2 learners during the perception of L2 sounds. Most studies provide evidence about cue-reliance during the discrimination of L2 contrasts rather than during cross-linguistic categorization of L2 sounds. For example, Kim *et al.* (2018) examined the changes in cue-weighting strategies of adult and child Korean learners of English with respect to English contrastive vowel pairs. The results showed that both populations of Korean learners used both spectral and duration cues to distinguish /i/-/ɪ/ but they relied only on duration to discriminate the English /e/-/æ/ contrast. With respect to cross-linguistic cue-reliance, there is much evidence that L2 speakers tend to assimilate L2 sounds to the spectrally closest phonological categories of their L1 (see Georgiou, 2018b; Escudero *et al.*, 2014). Nevertheless, not much studies examined whether speakers rely or not on durational cues during the categorization of L2 sounds. Lengeris (2009) investigated the perception of English vowels by both Greek and Japanese speakers to conclude that both populations of learners relied on both spectral and duration cues during the classification of L2 vowels to their L1 system.

The purpose of the present study is to investigate the assimilation of English vowels and the discrimination of English vowel contrasts by children who learn English as foreign language in Cyprus, and to determine the cue-reliance of L2 learners during vowel categorization. This study is expected to contribute significantly to the large body of research on cross-language speech perception since it investigates vowel perceptual patterns of an under-researched population (children aged 8-12) in a relatively under-researched context (foreign language instruction rather than L2 immersion). Furthermore, the languages involved, that is Cypriot Greek and English, have not been investigated much in the literature. The same participants that took part in Georgiou (2019a) also participated in this study. Both low and high proficiency learners of English in Georgiou (2019a) had significant difficulties in perceiving the acoustical differences of specific English vowel pairs; however, this study does not take into account the learners'

proficiency level but only children's general perceptual patterns. Lengeris (2009) investigated the perception of English vowels by adult Greek speakers to conclude that many English vowels were assimilated to a single Greek phonological category, e.g., /i:/ and /ɪ/ were both assimilated to the Greek category /i/, English /ɛ/ and /ɜ:/ to Greek /e/, English /æ/ and /ʌ/ to Greek /a/, English /ɑ:/, /ɒ/, and /ɔ:/ to Greek /o/, and English vowels /ʊ/ and /u:/ to the Greek phonological category /u/. The author added that most of the English contrasts showed low to moderate discrimination scores.

We selected children instead of adults in order to examine the perceptual abilities of this population of learners who are believed to acquire a nonnative language with less effort than adults (Snow, 1987). In any case, children differ to a great extent from adults in the way they process speech sounds. For example, perception of synthetic vowels by 3-year-olds relies more on dynamic spectral change information than adults (Murphy *et al.*, 1989), while perceptions of 5-11 year-olds are more influenced by the duration of stimulus and the consonantal context compared to adults (Ohde *et al.*, 1996). This is to say that children's perceptual patterns are not yet adult-like (Walley, 2005); they are not segmental but holistic since they are conducted on the basis of information distributed through the speech signal. Similarly, De Cara and Goswami (2003) point out that children's lexical representations differ from those of adults in that they are holistic, that is, children do not pay attention on particular phonemic contrasts but in other features such as prosody when they produce speech. This seems to change only when they get mature, and gain more linguistic experience. Also, the expansion of lexicon plays an important role since it forces speakers to give more emphasis on the phonetic details of the speech signal. In that way, their holistic representations are restructured and thus smaller segments of sounds such as syllables and finally phonemes are represented (De Cara and Goswami, 2003).

2. CYPRIOT GREEK AND ENGLISH VOWEL SYSTEMS

The Cypriot Greek vowel system consists of 5 pure vowel phonemes /i e a o u/ without short-long or tense-lax distinctions (Georgiou, 2018b). On the contrary, English vowel system (Received Pronunciation) consists of 11 monophthongs which can be either tense /i: ɜ: ɑ: ɔ: u:/ or lax /ɪ ʊ e ə ʌ ɒ/ (Roach, 2004). Tense vowels are longer than lax vowels. However, in many contexts (e.g., before voiceless obstruents) vowel length differences between tense and lax vowels are neutralized. It is evident that the English vowel inventory is more complex than the Cypriot Greek one since more acoustic features are needed to describe it.

Specifically, the two vowel systems differ both in “density” (5 vs. 11 vowels) and in that specific vowels in each of them differ considerably in terms of phonetic features (for the role of vowel system “density” in speech perception and production, see Meunier *et al.*, 2003).

The predictions about the assimilation of English vowels and the discrimination of English vowel contrasts by Cypriot Greek speakers will be developed on the basis of the PAM-L2 which makes predictions about the perception of contrasts by L2 learners. To this purpose, we have to take into consideration the acoustic properties of both Cypriot Greek and English vowels in the common phonological space. Considering the articulatory/phonetic features of the aforementioned languages, we can conclude that the English vowels /i:/ and /ɪ/ will be assimilated to the Cypriot Greek phonological category /i/. However, bearing in mind that there is evidence that L2 learners rely on both spectral and temporal cues even if there are no temporal distinctions in their native language (Lengeris, 2009) we assume that /ɪ/ will be good exemplar of the Greek /i/ since they match for duration while /i:/ will be a moderate exemplar of that Greek category. The English vowels /ɛ/ and /ɜ:/ are expected to be assimilated to the Greek /e/ with the former English vowel to constitute a good exemplar of that category while the latter to constitute a bad exemplar of it. The English vowels /ʌ æ ɑ:/ are predicted to be assimilated to the Greek /a/ due to their close phonetic distance. Nevertheless, only /ʌ/ and /æ/ are expected to be good exemplars of the Greek /a/ since they have close durations with that Greek vowel while /ɑ:/ might constitute moderate exemplar of it due to its temporal difference. Also, the English /ɒ/ and /ɔ:/ are hypothesized to be assimilated to the Greek /o/ as two different exemplars of that category due to their temporal difference. Lastly, the English vowels /ʊ/ and /u:/ are expected to be assimilated to the Greek vowel /u/ both as different exemplars of that Greek phonological category: the former as a good exemplar of it since they have close durations and the latter as a moderate exemplar of it.

With respect to the discrimination of the English vowel contrasts: /i:/- /ɪ/, /e/- /ɜ:/, and /ɒ/- /ɔ:/, we expect a CG assimilation type with moderate (to good) discrimination of these contrasts since both members are predicted to be assimilated to the same Greek phonological category as two different exemplars of that category. However, for the English vowel contrast /æ/- /ʌ/, it is expected a SC assimilation since both of its members are predicted to be assimilated to the same Greek phonological category as equally good exemplars of it. At this point, we do not assume that learners will form novel phonological categories since they do not have much experience with the foreign language. Figure 1 illustrates the F1 and F2

of Cypriot Greek and English vowels as produced by their respective native speakers (Georgiou, 2019a). Figure 2 and 3 illustrate the durations of Cypriot Greek and English vowels as produced by their native speakers respectively (Georgiou, 2019a).

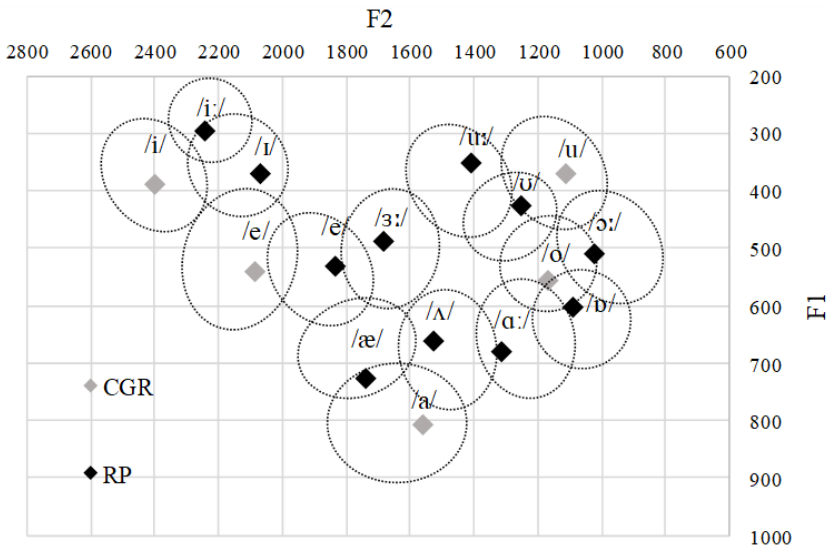


Figure 1. $F1 \times F2$ of Cypriot Greek (CGR) and English (RP) vowels as produced by their respective native speakers (Georgiou, 2019a).

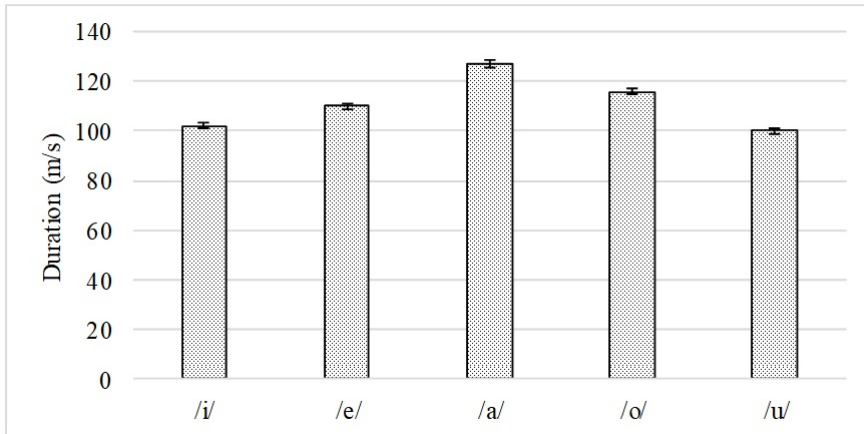


Figure 2. Mean values (in m/s) and SDs for the durations of the CGR vowels as produced by young native speakers of CGR (Georgiou, 2019a).

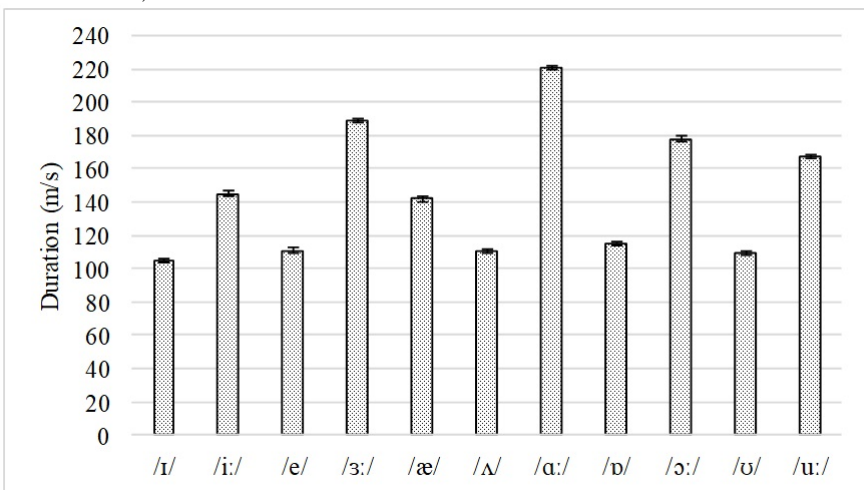


Figure 3. Mean values (in m/s) and SDs for the durations of the RP vowels as produced by young native speakers of RP (Georgiou, 2019a).

3. METHODOLOGY

3.1. Participants

Twenty-six subjects aged 8-12 years participated in the study (the same participants as in Georgiou, 2019a). Specifically, there were six 8-years-olds, seven 9-years-olds, five 11-years-olds and eight 12-year-olds. We selected only female speakers in order to minimize gender-based bias that may affect L2 vowel perception. Their native language was Cypriot Greek as they were born and raised in Cyprus. The participants were residents of urban areas of Larnaca city, Cyprus and they originated from moderate-income families. Although children's proficiency level differed, further evidence suggests that the effect of proficiency level on the speech perception of these learners was minimal since learners did not receive any pronunciation instruction and their teachers were nonnative speakers of English (Georgiou, 2019a). All of the children started to learn English at the age of 7 ($M_{age} = 7.3$) by attending courses at school and at private institutes. Their contact with English was mainly through foreign language courses since they were not practicing their English much in their daily life (e.g., by reading English books, by watching English movies, etc.). Also, the majority of the children reported that they often listen to the music, listening mostly to Greek music and to a lesser extent to English music. None of the children had any knowledge of any foreign language apart from English. Finally, all subjects reported that they had a normal hearing and they never had any language disorder.

3.2. Stimuli

One 10-year-old female native speaker of British English produced the stimuli of the perceptual assimilation task and her productions were recorded via Zoom audio recorder (44.1 kHz sample). The stimuli of the AXB discrimination task were recorded again by the same speaker as in the assimilation task (all A, X, B were produced by the same speaker as well). The stimuli were monosyllabic words consisting of 11 English (Received Pronunciation) monophthongs (/ɪ ʊ e æ ʌ ɒ i: u: ɜ: ɔ: ɑ:/) in the frame of /bVd/ (real words). For the discrimination task, only 4 English vowel contrasts were chosen: 1) /i:/- /ɪ/, 2) /e:/- /ɜ:/, 3) /æ:/- /ʌ/, and /ɒ:/- /ɔ:/; all of these contrasts were predicted to be difficult to discriminate by the learners.

3.3. Procedure

The perceptual assimilation task was created in PRAAT (Boersma and Weenink, 2018) and the script included orthographical transliteration of the 5 Greek vowels

(e.g., “i”, “ε”, “α”, “o”, “ou”). The participants were seated in front of a laptop and they listened to the English stimuli at a comfortable level (75dB) via the headphones that were connected to the laptop’s loudspeakers. Then, they were told to click on the Greek vowels in the script that are acoustically closer to the English vowels they heard. After choosing the vowel, they were told to rate it by clicking on one of the script options (scale 1-5: 1 = very poor, 5 = very good), depending on how good exemplar of the corresponding L1 vowel the English vowel was. It was included a 5-point scale (as in Georgiou, 2018b, 2019a) instead of a 7-point one since we wanted to make it quite simple for the children to read out the complete list of scale descriptors and thus respond better (Dawes, 2008). In total, 44 tokens were presented to the subjects (11 vowels × 4 repetitions) and they had 5 seconds to assimilate each vowel with an optional 2-minute break at the midpoint. The task was accomplished in a sound attenuated room.

After the perceptual assimilation task, learners completed an AXB discrimination task (4 trials: AAB, ABB, BBA, BAA; where A and B represent different English words having different vowels) (Best *et al.*, 2001) in a sound-attenuated room. The task was completed on a PC monitor using a PRAAT script (the script displayed the labels “first” and “third”). The subjects of the study were informed that tokens A and B were acoustically different vowels and that vowel X was the same as A or B. The participants were listening (at a listening volume of 75dB) to a triad of words that contained the target English vowel contrast (e.g., for the /ɜː/-/e/ contrast: /bet/ - /bet/ - /bɜːt/) through headphones that were connected to a laptop. Then, they were instructed to choose by clicking on the script labels whether the middle sound was the same as the first or the third sound. They had to discriminate a total of 64 items (4 trial types × 4 vowel contrasts × 4 repetitions) with an optional brake after the 32nd item. The interstimulus and intertrial intervals were 2s and 7s respectively.

4. RESULTS

A vowel was considered as “categorized” if the same category label was selected on at least 70% of responses (following Georgiou, 2019a, 2018b). The findings indicated that two or more English vowels were assimilated to a single Cypriot Greek phonological category. As it can be seen from Table 1, English vowel /i/ was assimilated to the Cypriot Greek phonological category /i/ while English /iː/ was assimilated to the same phonological category. English vowels /e/ and /ɜː/ were both assimilated to the Cypriot Greek /e/. Also, English /ʌ æ aː/ were assimilated to the Greek /a/, and English vowels /ɒ ɔː/ to the Cypriot Greek /o/. Lastly, English /ʊ uː/ were assimilated to the Greek /u/. So, within-category

assimilations emerged for the English vowel contrasts /ɪ/ - /i:/, /e/ - /ɜ:/, /ʌ/ - /æ/, /ʌ/ - /ɑ:/, /ɑ:/ - /æ/, /ʊ/ - /u:/, and /ɒ/ - /ɔ:/.

CGR vowels	RP vowels										
	/ɪ/	/i:/	/e/	/ɜ:/	/ʌ/	/æ/	/ɑ:/	/ʊ/	/u:/	/ɒ/	/ɔ:/
/i/	95 (2.9)	100 (4.4)	17 (1.5)								
/e/	5 (1.8)		83 (3.5)	70 (2)	16 (1.6)	8 (2.5)					
/a/				30 (1.6)	84 (4)	92 (4.2)	80 (3.9)			13 (2.2)	
/o/							19 (1.6)	24 (1.9)	1 (1.3)	85 (3)	81 (2.7)
/u/								85 (2.9)	100 (4.6)	3 (1.6)	19 (2.5)

Table 1. *Percentage of the assimilation of the English vowels to the Cypriot Greek phonological categories. In brackets, the goodness of fit ratings are indicated (1= very poor, 5=very good). The bold cells represent the predicted assimilations while the blank cells show that the assimilation was below 1% to that vowel category.*

To investigate further the overall fit of English vowels to the Cypriot Greek phonological categories, “fit indexes” were developed (see Guion *et al.*, 2000). The fit indexes combine the identification and goodness of fit rating data into a single metric. For example, the fit index of the English vowel /ɜ:/ (1.4) emerged by multiplying its proportion of identification (0.7) with its goodness of fit rating (2). Fit indexes are shown in Table 2. It is assumed that English vowels with high fit indexes can be accepted as good instances of Cypriot Greek phonological categories while low fit indexes signify that English vowels are distorted instances of Cypriot Greek categories. The mean fit index of all English vowels was 3.1 (SD = 1). When an English vowel fell within 1 SD from the mean fit index of all English vowels, then it was classified as a “good” instance of a Cypriot Greek phonological category (2.1 and over). When an English vowel fell within 2 SDs from the mean fit index of all English vowels, then it was classified as a “fair” instance of a Cypriot Greek phonological category (1.1-2).

English vowel	Most common identification	Proportion of identification	Goodness of fit	Fit index	
i:	i	1	4.4	4.4	Good /i/
ɜ:	e	0.7	2	1.4	Fair /e/
ɑ:	a	0.8	3.9	3.1	Good /a/
ɔ:	o	0.81	2.7	2.2	Good /o/
u:	u	1	4.6	4.6	Good /u/
ɪ	i	0.95	2.9	2.8	Good /i/
e	e	0.83	3.5	2.9	Good /e/
æ	a	0.92	4.2	3.9	Good /a/
ʌ	a	0.84	4	3.4	Good /a/
ɒ	o	0.85	3	2.5	Good /o/
ʊ	u	0.85	2.9	2.5	Good /u/

Table 2. *Fit indexes emerged for English vowels in terms of Cypriot Greek categories. Only identifications that were more than 70% are included.*

The fit index provided that both members of the following within-category contrasts were perceived as good instances of the Cypriot Greek phonological category they were assimilated to: /ɪ/ - /i:/, /ʌ/ - /æ/, /ʌ/ - /ɑ:/, /ɑ:/ - /æ/, /ʊ/ - /u:/, and /ɒ/ - /ɔ:/. On the contrary, the members of the English contrast /e/ - /ɜ:/ were assimilated as good and fair instances of the Cypriot Greek /e/ category respectively. However, fit indexes provided only a general picture of how do English vowels fitted to the learners' L1 phonological system with the majority of them to have been perceived as "good" instances of Cypriot Greek categories. In order to determine the exact assimilation pattern of within-category assimilations (which can be either SC or CG), *paired-sample t-tests* were used for the goodness of fit ratings of vowels that were assimilated to the same Cypriot Greek phonological category. If the vowels' goodness of fit ratings do not differ, then learners are not able to perceive the phonetic differences between the two sounds; in this case, a SC assimilation will occur. By contrast, if the vowels' goodness of fit ratings differ, then learners are able to perceive the sounds' phonetic distance; a CG assimilation will take place. The results showed significant differences for the goodness of fit ratings of /ɪ/ - /i:/, [$t(25) = 1.33, p=0.01$], /e/ - /ɜ:/ [$t(25) = - 0.91, p=0.01$], and /ʊ/ - /u:/ [$t(25) = 2.07, p=0.001$]; all these contrasts signaled a CG assimilation type. The other contrasts, namely, /ʌ/ - /æ/, /ʌ/ - /ɑ:/, /ɑ:/ - /æ/, and /ɒ/ - /ɔ:/ signaled a SC assimilation since their goodness of fit ratings did not differ.

Table 3 shows the discrimination of the 4 English vowel contrasts under investigation. In general, the discrimination patterns of Cypriot Greek learners of

English ranged from poor to moderate; poor for /æ/ - /ʌ/ and /ɒ/ - /ɔ:/ contrasts and moderate for /ɪ/ - /i:/ and /e/ - /ɜ:/ contrasts. Specifically, the two CG contrasts could be discriminated almost with the same manner but more accurately (68 and 70%) than the SC contrasts (55 and 52%).

Vowel contrast	Type	Correct (%)	SD
/ɪ/ - /i:/	CG	68	1.2
/e/ - /ɜ:/	CG	70	2.1
/æ/ - /ʌ/	SC	52	1.3
/ɒ/ - /ɔ:/	SC	55	1.6

Table 3. Percentages of correct responses and SDs with respect to the discrimination of English vowel contrasts by Cypriot Greek learners of English.

A one-way repeated measures ANOVA was carried out in order to examine the effect of vowel contrasts on the discrimination scores with *Discrimination Score* as the dependent variable (percentages of correct responses) and *Contrast* as the within-subjects factor (4 vowel contrasts). The results showed a significant effect of *Contrast* on the *Discrimination Score* [$F(3, 72) = 5.69, p = 0.001, \eta^2 = 0.13$]. Further checks with the Bonferroni correction showed significant differences between the /ɪ/ - /i:/ ($M=68\%$) and /æ/ - /ʌ/ ($M=52\%$) ($p=0.001$), /ɪ/ - /i:/ ($M=68\%$) and /ɒ/ - /ɔ:/ ($M=55$) ($p=0.001$), /e/ - /ɜ:/ ($M = 70\%$) and /æ/ - /ʌ/ ($M=52\%$) ($p=0.001$), and /e/ - /ɜ:/ ($M = 70\%$) and /ɒ/ - /ɔ:/ ($M=52\%$) ($p=0.001$). Therefore, the CG contrasts had significantly higher scores than the SC contrasts.

For determining the relationship between identification and discrimination scores, *Pearson r* correlation tests were used. The sum of percentages of assimilation for two contrastive vowels (e.g., /ɪ/ and /i:/) by each individual were the one factor while the other factor included the percentages of correct discrimination responses for the same vowel contrast (e.g., /ɪ/ - /i:/) by each individual. The findings showed that there was a positive correlation between the identification and discrimination scores for /ɪ/ - /i:/ ($r = 0.52, p = 0.01$), /æ/ - /ʌ/ ($r = 0.34, p = 0.03$), and /ɒ/ - /ɔ:/ ($r = 0.39, p = 0.001$), but a non-positive correlation for /e/ - /ɜ:/ ($r = 0.55, p = 0.13$). Therefore, for the majority of the contrastive pairs, the findings indicated that individuals who were more consistent in their cross-language classification of vowels were more apt to discriminate them accurately.

5. DISCUSSION

The present study investigated the assimilation of English vowels to the Cypriot Greek phonological categories and the discrimination of English vowel contrasts by Cypriot Greek children who learn English as a foreign language. In general, our initial assimilation predictions were confirmed since they assimilated two or more English vowels to a single phonological category of their native language: English /ɪ i:/ were assimilated to Greek /i/, English /e ɜ:/ to Greek /e/, English /ʌ æ a:/ to Greek /a/, English /ʊ u:/ to Greek /u/ and English /ɒ ɔ:/ to Greek /o/. These findings agree to a great degree with the results found by Lengeris (2009) who investigated perceptual patterns of English vowels by Greek adults. This is to say that perceptual patterns did not differ a lot between adult and children learners of English since both populations of learners had similar English vowel assimilation patterns in the two studies.

Also, as expected, learners did not establish new phonological categories for the L2 vowels (but merged L1-L2 categories) since they still have limited linguistic experience in the L2. It is widely showed in several cross-linguistic studies (e.g., Strange, 1995; Escudero, 2009) that speech perception is shaped by experience in the fine-grained acoustics of a specific language environment. Escudero (2009) pointed out that speech perception depends on language-specific acoustical mappings and it is not performed solely by our general auditory system. It has to be considered that the children of this study were attuned to the acoustic features of their native language while the acquisition of speech stimuli in the L2 was very limited since they were receiving English input mainly through the classroom. In terms of the L2LP, this would be a “new scenario” since children assimilated many L2 categories to a single L1 category and thus will face many perceptual difficulties. In general, the findings of this study provide further evidence that learners with an L1 vowel system that differs significantly in terms of phonetic features with the L2 vowel system and which is smaller in size than the vowel system of the L2 make multiple assimilations to a single L1 phonological category, struggling to perceive much phonetic difference between two acoustically different L2 sounds. Meunier *et al.* (2003) observed an effect of perception when the L1 of the learners differed in formants but not in size. However, we cannot be sure whether the perceptions of this study were influenced by the low density of the Greek vowel system or by the phonetic differences between the vowel systems of the two languages.

The most difficult vowel contrasts for the learners were the /ʌ/ - /æ/, /ʌ/ - /ɑ:/, /ɑ:/ - /æ/, and /ɒ/ - /ɔ:/ since they could not perceive their between phonetic differences

as an influence from their already formed L1 phonetic units; we prompt that none of these vowels is present in the Greek phonological system. According to the PAM-L2, learners might be able to develop novel phonological categories for these sounds in the future, and thus, discriminate their phonetic differences, under specific circumstances. For example, phonetic training is believed to be efficient for the improvement of both perceptual and production skills of the learners with respect to L2 phones (Best and Tyler, 2007).

It is remarkable that contrast members that were longer were rated as better exemplars of a Cypriot Greek phonological category than contrast members that were shorter. For instance, the English /i:/ was judged as a significantly better exemplar of the Greek /i/ ($M=4.4$) than the English /ɪ/ ($M=2.9$) despite the fact that the English /ɪ/ has closest duration with that Greek vowel than the English /i:/. This is inconsistent with our initial predictions that a temporal match between an L1 and an L2 vowel would make the L2 vowel fit better on a spectrally close L1 phonological category. Perhaps, learners rely more on spectral cues during speech perception, a conclusion that is in contrast with the findings reported in Lengeris (2009). Also, we do not exclude that the articulation of long vowels might aid listeners have a clearer picture of their acoustic features driving them in that way to recognize these vowels as good exemplars of native phonological categories.

The findings are also offered for the evaluation of PAM-L2 discrimination predictions. According to the results, the contrasts that signaled a CG assimilation type could be discriminated with a moderate manner (~70%) while contrasts that signaled a SC assimilation type had a poor discrimination (<60%). Also, the statistical analysis showed significant differences for the discrimination scores of CG and SC assimilations; CG assimilations could be discriminated more accurately than the SC assimilations. These findings coincide with the hypotheses of the PAM-L2 that predicts a moderate (to good) discrimination of the CG contrasts and a poor one for the SC contrasts; this relationship can be depicted on the following formula: $CG > SC$. This relationship is also evident in the results of other studies such as Georgiou (2018b) and Mahmoud (2013). Thus, both within-category assimilations, namely CG and SC may differ in terms of discrimination accuracy depending on the perceived phonetic similarity of the L2 sounds that were assimilated to the same L1 phonological category. Another important point is that the cross-linguistic assimilation of L2 vowels to the learners' L1 phonological categories was related with their ability to discriminate L2 vowel contrasts. Learners who were more consistent in the assimilation of two contrastive L2 vowels to their L1 system were more accurate in the discrimination of these vowels. Therefore, it was detected a relationship between assimilation and

discrimination scores proposing that assimilation tests may be predictive of the learners' ability to discriminate L2 sound contrastive pairs.

6. CONCLUSIONS

This study indicated the interference of the Cypriot Greek vowel system in the perception of the English vowels by Cypriot Greek children who learn English as a foreign language in Cyprus. It was found that children relied on spectral cues in order to assimilate L2 vowels to their L1 phonological system. Furthermore, it is suggested that small size vowel inventories pose a degree of difficulty with respect to the perception of nonnative sounds. The absence of much experience in the L2 is a significant factor that prevents the formation of new phonetic categories for L2 sounds that are dissimilar from any L1 sound. However, more factors that affect L2 vowel perception have to be taken into consideration in future studies such as learners' proficiency level, vocabulary size in the L2, context of the stimuli provided (e.g., preceding or following consonant), etc. Also, it is assumed that children might not have the same metalinguistic capacity due to age-related differences and therefore they might differ as well in speech perception; a future perceptual study should take into consideration children's metalinguistic skills.

Furthermore, the uncovering of these difficulties can offer significant feedback for speech pedagogy. For example, educators can focus on the acoustical differences of the aforementioned English vowel contrasts (e.g., by using minimal pairs) in order to make students perceive these differences (Georgiou, 2019b). There is evidence that minimal pair training sessions improve learners' L2 pronunciation accuracy (Haghighi and Rahimy, 2017; Tuan, 2010). Also, teaching material could adapt to the needs of these learners and include activities that will enhance the perception of the phonetic details of the English vowels. For instance, more emphasis can be given on a vowel that is less perceivable than other vowels.

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