The Impact of Vowel Inventory Size and Linguistic Environment when Learning Two Languages: The Case of English and Greek

Eleni Galata

A thesis submitted for the degree of

Doctor of Philosophy (Ph.D.) in Psycholinguistics and Neurolinguistics

Department of Language and Linguistics

University of Essex

Date of resubmission for examination 17 December 2022

Abstract

Producing phonemic contrasts in two typologically different languages, can prove a difficult task for speakers of those languages, even experienced ones (for instance, Boersma & Escudero, 2008; Kivistö-de Souza & Carlet, 2014), from birth or otherwise. This thesis discusses the effects of linguistic environment and phonemic inventories in the production of British English vowels. Greek and English were chosen as a language pair for further investigation, due to the fact that their vocalic inventories differ significantly in terms of the number of phonemes each has, the phonemic categories identified, as well as the vowel features in each. In order to explore the role of the linguistic environment, groups of bilingual Greek - English children based in the United Kingdom and in Greece took part in the first round of experiments. In order to explore further the role of phonemic inventories a group of native Greek second language learners of English also took part in the same set of tasks. The productions of British English vowels and vowel contrasts by each participant group was assessed by a series of speech production tasks analysing acoustic properties of the vowel categories in question. Bilingual children in Greece performed in a similar manner to monolingual controls, however, children raised in the UK deviated from monolingual norms. Quality of input and amount of exposure to each language in the two linguistic environments seem to be predicting factors for vowel production outcomes. Native Greek second language learners of English produced British English vowels similarly to monolingual controls when it came to both spectral and temporal cues. This could be attributed to the amount of experience second language learners had with English

throughout their lifespan.

Key words: language learning, inventory, size, linguistic environment, exposure, second language, phonemes, vowels, sounds, phonology, phonological, English, Greek

Acknowledgements

Throughout the PhD journey, I received a lot of support from a number of people without whom this project would not have been possible. First and foremost, I would like to extend my gratitude to my supervisors, Dr. Claire Delle Luche, and Dr. Wyn Johnson: their feedback, comments, and recommendations helped shape this thesis and taught me a lot in the process, most importantly, to work independently, believe in my abilities, and not give up in the face of adversity. I am truly thankful to Dr. Lawrie Lawyer for her support with tackling statistics; she has welcomed me to her LG533 sessions, was patient with my queries, and encouraged me to face the data analysis once again with enthusiasm! Last but not least, gratitude is owed to my examiners, Dr. Vicky Chondrogianni and Dr. Faith Chiu. Their insightful comments, detailed corrections, recommendations for improvement, and questions have helped me refine my manuscript and produce what I hope is a better version of the original!

This venture would not have been as exciting without the unconditional support of my former supervisor, Dr. Sonja Eisenbeiß, to whom I owe so much. She has not only been a teacher to me, but also a mentor, councelor, and dare I write, friend. She has listened to my anxieties without complaint, both when she was close and from afar, has helped me regain my motivation in times of doubt, and has reminded me numerous times of how rewarding doing research with children is! I would be forgetful if I did not mention the yearly Toy Fair excursions in the UK and in Germany, chocolate treats, and evenings of creating language elicitation materials and brainstorming. For all these and more we have shared, I am grateful beyond words.

I would not have completed this thesis without the support of my participants and their families, in Greece, and the UK. Special thanks are extended to the Headteacher of Campion Junior School, Athens, Judith Whitehead, who responded to my call, welcomed me to her school, and permitted me to conduct research with her lovely students. Also special thanks are owed to the Headteacher of the Greek school at Bishop's Stortford, Essex, Markella Afenti, who brought me in touch with parents and children of the area who also participated in this study. To the hundreds of parents and children who took part in the pilot studies and the main study, to the students and employees at the University of Essex, to the members of the University of Essex Babylab who all responded to my call for participants and donated their time, thank you! Also, to the "Greek mums in Colchester" who turned out to be not only research participants, but a link to a community I did not know existed, and also friends! I would also like to thank Nicole, for coming to Essex as an excited Erasmus+ student and contributed to part of the data annotation and coding.

Apart from my mentors and participants, this journey would not have been complete without the support of my family, friends, and colleagues. Gratitude is first owed to my parents, Ilias and Maria, and brother, Thanasis for their unconditional love and support throughout this long journey and for always reminding me that I can do anything I set my mind to. Thank you to my school friends Maria, Nelly, and Vassia. You have been there for the past 18 years, through highs and lows, sent your love and thoughts from afar, and kept reminding me of all the relaxing holidays we would have once we submit our theses; this moment is finally so close!

Enormous thanks go to my support network in the UK. Without your patience, listening ears, advice, and support, this journey would not have been the same. Irini, thank you for being my "forever flatmate" and for going through the Essex adventure with me. Maria, thank you for the endless chats, the millions of unfinished topics, and your encouragement during the final stretch. Tuğba, thank you for checking on me, being supportive, and sending your positive vibes, thoughts, and love all the way from Turkey! Last but not least, gratitude is due to Liza and Chiara, for being there and listening. You never let me forget how it feels to have family away from home, you have been encouraging the moments I was considering giving up, and kept reminding me of the excitement I would feel once I submitted this work. Thank you for the wine evenings, amazing food, jokes, laughter, tears, and moments of sharing our thoughts and anxieties, which always concluded with: "life is too short not to enjoy yourself" and "everything will work out in the end".

Finally, thank you to my colleagues, Stephanie, Kirsty, and Aleks. Stephanie, we met because you responded to my call for participants, then again when I responded to yours, without even knowing I was "returning the favour"! After that, you also became an officemate, a colleague, a manager, and a mentor. Thank you for offering to help me with the workload at busy times and being patient listening to me saying "I need to submit my Thesis!" ! Kirsty, thank you for listening, for always texting to ask "how writing is going", for sending me motivational music to write to, and for reminding me, in your words, to *"try to really enjoy the writing process and see it as something you are crafting and making your own. You are making and creating a tool that will help educate others... what an amazing achievement and something to be proud of"*. Those words and your positive attitude helped me regain perspective and faith in my work during the final challenging months. To the "Divas", thank you for our friendship, chats, and support, especially during the pandemic. We started as colleagues but we are more than that now: friends I consider lucky to have and that I can count on, especially at difficult times.

Finally, my deepest gratitude is owed to my partner. You have been beside me unconditionally, without judgement, but with the outmost love and patience. You have listened to my worries countless times, encouraged me, cheered me on when things were getting stressful, kept reminding me of how difficult, yet rewarding, the path I chose is, and you were the rock I could lean on throughout the years of this journey. For all these, and so much more, thank you.

Contents

Chapter 1

Introduction

The thesis is fundamentally about how bilingual and second language learners who transition from a small vowel inventory in their native language to a larger one in their second language produce vowel contrasts that do not exist in their first language. Therefore, this thesis addresses the following topics: vowel systems, acoustic properties of vowels, and second language learning at different stages in the lifespan,. It also discusses models of speech perception and production, as well as pronunciation.

So far, there has been an abundance of evidence on pronunciation patterns in bilinguals and second language learners, the difficulties experienced, and the reasons contributing to a detectable “foreign” accent. Contributing factors such as age of acquisition and first exposure (Asher & García, 1969; DeKeyser, 2000; Johnson & Newport, 1989; Munro, Flege, & MacKay, 1996 and others), learning processes (Cook, 1977; DeKeyser, 2009), or motivation (Alizadeh, 2016; Nance, McLeod, O’Rourke, & Dunmore, 2016; Saranraj & Shahila, 2016) have been put forward as factors affecting second language speech production and why it might deviate from monolingual norms. The inspiration for this thesis though, originated from the observation that highly experienced second language speakers of English who have lived in an English-speaking environment for several years, maintained a detectable accent and pertained to the pronunciation patterns of their native language, especially when it came to the pronunciation of specific sounds, most frequently vowels which are part of pairs in English such as /ɪ-iː/.

This generated the question of which sounds could be considered "difficult" by L2 speakers and the reasons behind this struggle. Indeed, reasons related to differences between languages' phonological systems have also been identified in the literature, where issues like contrasting phonological features between languages, the size and organisation of phonological inventories, and the existence or absence of specific phonemes between languages have also been put forward as elements that might pose problems when it comes to acquiring a new language.

A number of studies comparing bilinguals' and second language learners' responses to languages comprising phonemes different to their native language have found that specific contrasts or phonemes are difficult for both naïve and experienced speakers of a new language. For instance, Uribe Enciso, Hernandez, Smith, Pabón, & Steve (2019) reviewed both theoretical and empirical accounts that helped identify that Spanish speakers of English find "problematic" those English vowels that are either absent from the Spanish inventory or present different characteristics to Spanish ones, due to the difference in inventory size between Spanish (small inventory) and English (large inventory). Those phonemes would be those not belonging to the Spanish vowel inventory (/ɪ/, /ɜː/, /æ/, /ɒ/, /ə/, /ʊ/). Apart from Spanish, German speakers of English have also been found to struggle with phonemes that do not exist in their native language inventory. Llompart, & Reinisch (2019) found that adult German native speakers who learn English find the contrast between /ɪ/ and /i/ easy to perceive and produce due to the fact that the same contrast exists in their native language inventory. Instead, the English contrast between /ɛ/ and /æ/ poses perceptual and production difficulties to adult German second language learners of English, because /æ/ is not part of the German phonemic inventory.

Apart from variation of phonetic categories in two languages, the overall organisation and size of phonemic inventories has also been found to affect phoneme acquisition in a new language. Production studies with speakers of languages with large inventories, such as German or English have demonstrated that those speakers expand their acoustic space to produce vowels with larger acoustic differences, as opposed to speakers of languages with small inventories, such as Spanish (Harris, 1969) or Italian (Bertinetto & Loporcaro, 2005).

Souza, Carlet, Julkowska, and Rato, (2017) found an advantage for speakers of languages with larger inventory sizes when learning a new language, as those seem to have experience in attuning to fine spectral and temporal differences from their native language, therefore having a seemingly simpler task than those speakers of languages with small inventory sizes. For instance, native speakers of English can easily make the distinction between /ɪ/ and /iː/ both while perceiving the contrast, by making use of spectral cues, relevant to vowel quality, and while producing it (Bohn & Flege, 1990; Escudero & Boersma, 2004). However, speakers of languages who do not have a contrast between tense (vowels that are produced after tensing of the vocal folds; Ladefoged, 2009) and lax vowels (vowels that are produced with the vocal folds being "relaxed", without tensing, ibid.) such as Spanish have been found to employ temporal cues, relevant to vowel duration, while perceiving the contrast (Bohn, 1995; Flege, Bohn, & Jang, 1997) and have been unable to produce the contrast successfully too (Cebrian, 2007; Kondaurova, & Francis, 2008).

One of the explanations put forward by, for instance, Boersma and Escudero (2008), Kivistö-de Souza, & Carlet (2014) and others for the reliance on temporal cues is inventory size, in that in languages with small vowel inventories and varying organisation, speakers get "desensitised" in small-scale spectral differences and focus on more salient ones, such as duration (Bohn, 1995; Souza et al., 2017). Languages' phonemic inventory sizes have even been found to yield neurophysiological responses due to their size and organisation. In Hacquard, Walter, & Marantz, (2007), for example, perceptual sensitivity was identified in French speakers, who are accustomed to a large vowel inventory, for those vowels that fell within the same category, as opposed to Spanish speakers, who, being exposed to a small vowel inventory in their native language, perceived acoustically different sounds as belonging to the same category.

Perceptual advantages for second language speakers being familiar with a large inventory in their native language and being exposed to a small inventory in a new language, have been identified in other language combinations too, among others, German, Mandarin, and Spanish (Bohn, 1995), English and Spanish (Fox, Flege, & Munro, 1995), French and Spanish (Hacquard et al., 2007), Spanish, French, German, and Norwegian (Iverson & Evans, 2007), Danish, Portuguese, Catalan, Russian, and English (Souza et al., 2007). In terms of comparing the language pair of Greek and English, few studies have done so, those of Lengeris and Hazan (2010) and Georgiou (2019).

1.0.1 Vowel Classification and Coding

Conventionally, phonemes are symbolised by means of the International Phonetic Alphabet (henceforth IPA) notations, which is also the case in this thesis. Since the system's first publication in 1888 (Passy, 1888), it has been widely used to represent spoken language in a standardised manner and represent the pronunciation of phonemes with shared characteristics across languages. Using symbols comprising letters of the Roman alphabet and diacritics to represent features of oral speech has contributed to its popularity. Features such as length, aspiration, voicing, articulation and co-articulation can be represented through IPA notation

(Wells, 2006). Other features, such as word stress, are represented with diacritics (Duckworth, Allen, Hardcastle, & Ball, 1990). In those cases, narrow phonetic transcriptions could be used as a better alternative, to represent allophonic variation more accurately.

Since the overarching theme of this thesis is vowel productions in small and large language inventories, the language pair compared in this study was Greek[1] and British English[2], which differ in terms of inventory size and individual vowel characteristics. Greek has a standard 5-vowel system (Arvaniti, 1999; 2007; Mackridge, 1985; Newton, 1972; Trudgill, 2009, among others), while the British English system comprises a larger and more complex system, including low front, mid-central, and low back vowels that are not part of the Greek vocalic inventory (for instance, Roach, 2004; 2009). In British English, there are also tense-lax vowel contrasts, another feature that does not exist in Greek. For example, for the British English vowels /ɪ/ and /iː/, there is only one Greek vowel equivalent, /i/.

1.0.2 Research questions

This work has been driven by an interest in the role the size of phonological inventories play as well as how exposure to different linguistic environments through residence in countries with different dominant languages affects the production of vowel contrasts. In order to address those topics, I decided to first provide an acoustic description of the SMG vowel system, as a better understanding of the system and an up-to-date description were necessary. Therefore, one of the questions this thesis will attempt to address is a way to provide a comprehensive description of the SMG vowel space. Another issue that has been identified is

[1] Standard Modern Greek (SMG) and Greek will be used interchangeably in the thesis for convenience. In both cases, the variety mentioned is the Standard one, largely spoken in mainland Greece, which has no regional influences.

[2] Similarly to Greek, the variety studied in the thesis is the Standard Southern British English (SSBE) variety. The terms British English (BA) and English will also be used interchangeably.

that the IPA system might not be the best tool to represent low central vowels, especially in smaller inventories, which generated the question whether there is a better alternative to the IPA system. Both questions are going to be addressed in the first paper of the thesis.

The SMG vowel inventory size and description lead to the question of what happens when speakers are exposed to a language with small inventory size and one with a larger one at the same time. So far, literature on bilingual speech performance has been focusing on aspects such as the role of age (Asher & García, 1969; DeKeyser, 2000; Johnson & Newport, 1989; Munro, Flege, & MacKay, 1996 and others), or dominance of one language over the other (Amenguel- Watson & Chamorro, 2015; Molnar, Lallier, & Carreiras, 2014; Moyer, 2011; Birdsong, 2014), while, to my knowledge, the role of the linguistic environment has been neglected in recent studies. Therefore, a question that I wanted to answer in this thesis was indeed whether the environment bilinguals grow up in plays a role in their productions of vowels. The question is going to be addressed in the second paper of the thesis.

Finally, apart from bilingualism, another question I tried to answer in this thesis is the speech production of second language learners who are native speakers of a language with a small vowel inventory and are exposed to a second language with vowel contrasts non-existent in their native one, and how they perform in it. The final question will be discussed in the last paper. In order to isolate the effects of language, we only examined vowel productions in British English, by examining bilinguals and second language learners of English. Participants took part in controlled and semi-controlled production tasks, from which we obtained formant values to acoustically analyse vowel productions and evaluate them against the productions of native English speakers. This allowed us to test whether the inventory size of the native/ most dominant language affects the distribution and positioning of the vowels on the vowel space.

1.0.3 Organisation of the Thesis

This thesis has taken the form of three papers addressing the topics outlined earlier. The first paper introduces an account of the Standard Modern Greek vowel system by reviewing the available literature to date and by offering a comprehensive account of the Greek vowel system based on acoustic findings. In that, the paper attempts to reconstruct the system's vowel space and make recommendations of an updated vowel chart based on up-to-date acoustic methods. The second paper moves on discussing the impact of the linguistic environment on the acquisition of British English vowels who grow up bilingual in two different environments by examining their vowel productions, followed by the last paper, which addresses the acquisition and production of British English vowels by second language learners.

Chapter 2

The Standard Modern Greek Vowel System: Insights from an Acoustic Perspective

Abstract

Although generally considered a standard 5-vowel system, the Standard Modern Greek vowels have been met with a degree of controversy, especially those found in the mid-low and central area of the acoustic vowel space. To my knowledge, studies on Greek vowels to date have been limited to either descriptive accounts (Dauer, 1980; Holton, Mackridge, & Philippaki-Warburton, 1997; Joseph & Philippaki-Warburton, 1987; Mackridge, 1985; Newton, 1972) or acoustic analyses using limited number of analysable tokens (for instance, Arvaniti, 1999; Botinis, 1981; Fourakis, Botinis, & Katsaiti, 1999 and others), which calls for a quantitative analysis of the Greek vowel system based on a more extended dataset. In order to comprehend the status of the Greek vowel system better, an acoustic analysis of the vowels' spectral and temporal properties was carried out, following the productions of 19 native Greek participants. This paper addresses topics such as acoustic characteristics of the Greek vowels, vowel space area, and physical

distance between the vowels on the vowel space. In order to enhance our overall understanding of the system, phenomena observed with the Greek vowels, such as allophonic variation, vowel deletion, and diphthongisation are also discussed.

2.1 Introduction

2.1.1 Standard Modern Greek: History and Development

Standard Modern Greek (henceforth: SMG or simpler, Greek) is the official language of Greece and the descendant of Ancient Greek. At present, it is the standard language variety spoken primarily in mainland Greece, and especially in its capital, Athens, and used by the majority of the population. The standard variety is also taught in schools, and used by the media and press not only by the nearly 12m Greeks within the country, but also wherever Greeks have emigrated, for instance, the US, across Europe, Australia and elsewhere. SMG has also been referred to as "Modern Greek common language" (*Neoelliniki Koini* - /nɛoɛliniˈki kiˈni/) (Newton, 1972) and should be distinguished from *(Katharevusa* - /kɐθɐˈrɛvusɐ/), an older, purist variety which had been used until 1976 and was highly influenced from Classical Greek.

To clarify, the linguistic situation in Greece was that of *diglossia*- two varieties being used- up until 1976: High *(Katharevusa)* and *Low ("Demotic Greek"* - /ði-motiˈki/) Greek (Mackridge, 1985; 2010). Katharevusa was mostly used in the literary texts of the era, and in official settings, such as in education, government, religion and so on. Presently, a simplified version of Katharevusa is often used by the clergy and in combination with Ancient Greek, in the Gospel. Other than those context-specific occasions, Katharevusa has been disused since 1976 and a new variety (Dimotiki) emerged, not only in oral communication as was the case until then, but also in writing.

Standard Modern Greek started developing from Dimotiki, the vernacular, when Athens became the official capital of the then "free Greek state" in 1833 (Kontosopoulos, 2001, p. 88). In the early days of Athens being the capital of the newly-founded state, residents of the Peloponnese, the Cycladic Islands, Evia, and Central Greece, and later the Ionian Islands, moved there and brought together their regional "idioms"[1]. Together with influences from dialects spoken in Constantinopole and Smyrni at the time, as well as from Katharevusa, Dimotiki became the most widely-used variety in Greece.

It is worth noting that although SMG is the most widespread variety, there are also other regional varieties, which present different characteristics to the standard form. For instance, Joseph and Tserdanelis (2003), as well as Trudgill (2003), following Newton (1972) identified the following dialects: Peloponnesian-Ionian (spoken in the Peloponnese and the Ionian islands), Northern (spoken in Epirus, Macedonia, and Evros), Cretan-Cycladic (spoken in Crete and the Cycladic Islands), and South-Eastern (spoken in the Dodecanese). Finally, Lengeris (2016) acknowledges cross-dialectal differences between Northern dialects, for instance, Kozani Greek, and Southern ones, such as Cretan Greek.

Although the scope of this paper is to discuss the SMG variety, it is worth mentioning briefly that phonological differences are identified between the Standard variety and regional dialects. For example, a dialectal difference specific to vowels is what Newton (1972), followed by Kontosopoulos (2001) and Krimpas (2019) identify as the *High Vowel Loss* in northern dialects of mainland Greece as opposed to the standard variety. This can be manifested as deletion of all unstressed /i, u/ and raising of /ɛ, o/ to /i, u/, for instance, /koˈritsi/ (girl) to /kuˈritʃ/ or deletion only of unstressed, word-final /i, u/ (/traˈpɛzi/ > /traˈpɛz/ (table)), which also

[1] An "idiom" in Kontosopoulos (2001) (p. 1) is a regional variety that although has noticeable differences to other varieties, it is mutually intelligible by both speakers and non-speakers of that variety

has implications for how those vowels are acquired and produced by speakers of northern dialects.

2.1.2 Overview of the Standard Modern Greek Vowel System

Characteristics in descriptive accounts

Previous accounts of the Greek vowel system have based their vowel descriptions on phonological features, such as frontness/ backness, lip rounding, and vowel height, from which I will start the description, before discussing what acoustic studies contribute to the debate (indicatively: Arvaniti, 2007; Joseph & Philippaki-Warburton, 1987; Joseph & Tserdanelis, 2003, Trudgill, 2003). The phonological accounts mentioned earlier, describe the system as a five vowel one, comprising the following vowels: /i/, /ɛ/, /ɐ/, /o/, /u/[2] which are organised in three degrees of height: high, mid, and low and two degrees of frontness: front and back (Newton, 1972; Joseph & Philippaki-Warburton, 1987; Joseph & Tserdanelis, 2003). Figure **??** demonstrates the vowel positions as described by Arvaniti (2007).

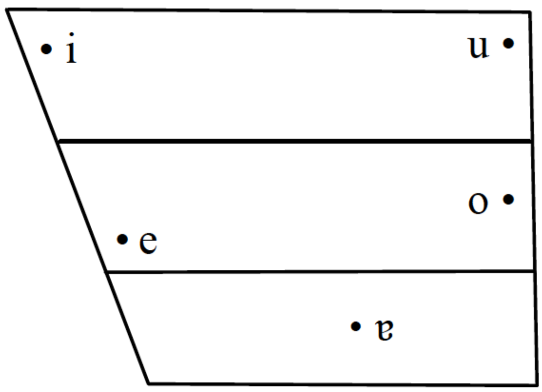


Figure 2.1: SMG vowel positions as proposed by Arvantiti (2007).

Addressing individual vowels starting from the high front position of the quadrilat-

[2]For the purposes of consistency, the IPA notation to be used throughout this paper will be based on the acoustical findings of the current study, although the rest of the reported IPA notations will be acknowledged too in this section.

eral, there is /i/, which is a high, front, unrounded vowel (Arvaniti, 2007; Samaras, 1974). At the high back position there is /u/, a high, back, rounded vowel (Arvaniti, 2007; Joseph & Philippaki-Warburton, 1987). However, there have been contradicting accounts on the status of the vowels in the mid and lower/ central areas of the quadrilateral, as there exist alternative notations and interpretations. For instance, in the front mid area there there is /ɛ/, a front vowel between open-mid and close-mid according to Arvaniti (2007) and Fourakis et al. (1999) or a higher and more centralised version (/e/) in Mackridge (2010). At the mid back area there is /o/, a mid back round vowel (Arvaniti, 2007; Fourakis et al., 1999; Hawks & Fourakis, 1995), which has also been characterised as a back open-mid vowel in Fourakis et al. (1999), Kaimaki (2015), and Nicolaidis (2003). Finally, in the low central area there is /ɐ/, the vowel that has been met with the most degree of controversy, in terms of both its height and backness. This is because a series of accounts describe the status of the vowel differently, hence a discrepancy in the vowel's symbolic representation too. For instance, Arvaniti (2007), Botinis (1981), Samaras (1974), and Tseva (1988) characterise the vowel as being between low-mid and low central (/ɐ/), while Mackridge (2010) place the vowel in a more centralised-back position (/a/), and Joseph and Philippaki-Warburton (1987) in a lower and back position, using the notation /ɑ/.

Characteristics in acoustic studies

Apart from looking at the SMG system as it has been presented in descriptive accounts of the language, it is also worth mentioning what studies with an acoustic focus have also found. Botinis (1981) for instance, providing acoustic data (formant frequencies) from the productions of five male speakers of Athenian Greek, i.e. the standard variety, found /ɛ/ to be higher and more centralised than what the previous descriptive accounts have mentioned (represented in the study as /e/) and /ɐ/ to be low central and towards the back (although symbolised as /a/). The acoustic study of Jongman, Fourakis and Sereno (1989), used the formant frequencies of the productions of 4 male native Greek speakers originating from Athens and Patras (both cities being in mainland Greece where the SMG variety is spoken) but residing in the US at the time of testing to provide insights on the vowel system. They characterised /ɛ/ a front mid open vowel, lower than what Botinis (1981) had found previously, and /ɐ/ to be low and central. Another study using 5 male speakers of the standard variety was that of Fourakis et al. (1999), whose characterisations following their acoustic analysis seem in line with the account of Botinis (1981). For the controversial vowels, /ɛ/ is found in the mid-central area of the vowel space and /ɐ/ in the low central area, also supported by the studies of Sfakianaki (2002), Nicolaidis and Rispoli (2005), and Nicolaidis (2003).

The lack of consensus on the status and transcription of the mid-front, mid-back, and central vowels could be attributed to a number of reasons. Some of the reasons are relevant to methodological issues in the description of the vowels. Most of the existing studies are quite dated, being conducted around the '70s till the late '90s, which might suggest a lack of consistency or accuracy in obtaining vowel measurements as well as a potential lack of a controlled environment. Equally, some descriptions on the status of the vowels are largely presented based on the authors' impressions of where the SMG monophthongs are placed on the vowel quadrilateral, rather than using acoustic data from speakers of the same variety. This is possibly due to the fact that in previous literature on SMG (indicatively, but not exhaustively: Newton, 1972; Dauer, 1980; Mackridge, 1985; Joseph & Philippaki-Warburton, 1987) there has been no clear distinction between the phonological and phonetic properties of the vowels. The vowels have so far mostly been described from a phonological perspective, taking into account the features that uniquely define each sound, such as frontness/ backness, lip rounding, height and so on, rather than using acoustic measures, such as data from spectrograms, waveforms, intensity curves, formant tracking and so on, which according to

Arvaniti (2007) are deemed more reliable and appropriate. Even older phonetic studies though, such as those of Arvaniti (1999), Botinis (1981), or Jongman et al. (1989) were limited in scope, in that they obtained acoustic measures from a small number of speakers (5 in Botinis, 1981; 4 in Jongman et al., 1989; and 2 in Arvaniti, 1999), with a limited number of vowel repetitions resulting in a small number of analysable vowel tokens. This could suggest that variability in the speakers' performance might have had an impact on the results obtained and larger-scale studies with a higher number of tokens might be necessary to provide more reliable findings.

Another methodological issue in previous studies that might have affected their robustness is that there has not been a clear distinction between phonology and phonetics and the implications of the studies' scope in the way vowels have been symbolised and described. Finally, the absence of up-to-date recording conditions during the experimental procedure is another reason why there needs to be a contemporary account of the Greek vowel system. In the study of Jongman et al. (1989) for example, male participants were asked to produce the 5 Greek vowels in words incorporated in carrier phrases. The words chosen were [ˈpita] (pie), [ˈpeta] (fly!), [ˈpata] (step on!), [ˈpote] (when?) and [ˈpuse] (where are you?); although included in consistent and controlled consonantal environments, the words themselves would not be produced in the same manner, as only one word ([ˈpita]) could have been produced in a neutral manner. The two following words were imperatives ([ˈpeta] and [ˈpata]), and the last two question words ([ˈpote], and [ˈpuse]), the productions of which might have been affected by the chosen word forms themselves. Besides, [ˈpuse] is a question word resulting from vowel deletion and is a contracted form (the original phrase being [ˈpu ˈise]?), which is another reason the vowel quality of /u/ could have been affected.

An additional reason that calls for clarity in the description of the SMG vowel system, especially for the controversial mid and central vowels, is the fact that Greek has been underrepresented in the literature, as it has typically been referred to as a "Standard 5-vowel system", often having been mentioned in parallel with Spanish. Such blanket characterisation can have implications in the better understanding of the SMG system, as important acoustic information might be neglected. To my knowledge, only one study has explicitly compared the acoustic characteristics of Greek and Spanish vowels, that of Fourakis et al. (1999), who upon comparing the two systems found some subtle differences in the formant measures of Greek and Spanish, with Greek vowels overall being placed in lower positions than Spanish ones, although individual vowels were assigned to the same categories.

The neglect of Greek in the literature over the abundance of sources for Spanish could be due to the fact that a large body of literature has focused on the written code, especially grammar, morphology, and syntax in Greek rather than phonology or phonetics and the norm has been to draw parallels to the Spanish vowel system as an alternative to describe the Greek vowels. An additional reason could be that Spanish is more widely-spoken, both by being the official language in more countries than Greek as well as having more speakers overall. The role of the system's dispersion on the vowel space and the distribution of phonetic categories is another area that has not been discussed extensively in the literature. Accounts such as that of Liljencrantz and Lindblom (1972) presuppose that phonetic categories in small systems, such as SMG, allow for maximal dispersion and distance between categories, although this has been challenged by later studies (Baltazani, 2007; Botinis, 1981; Disner, 1978; Papçun, 1976, Wood, 1975), which postulate variability in vowel dispersion depending on the acoustic characteristics and stress status of the vowels.

Finally, the controversial status of some Greek vowels could be attributed to the fact that the International Phonetic Alphabet (IPA) system (International Phonetic

Association, 2015), which has traditionally been used to represent phonemes of the world's languages, might not be an adequate tool in the presentation of phonetic categories, especially when it comes to representing the properties of the central vowels. The system, by using letters, symbols, and diacritics has tried to encapsulate both phonological and phonetic properties of phonemes. For vowels in particular, this is done with point vowels representing the placement of the tongue at the front or back of the oral cavity (International Phonetic Association, 1999). The front/ back dimension is illustrated with the horizontal axis: front vowels are produced with a fronting of the tongue dorsum, back vowels are articulated with the tongue body moving towards the back of the oral cavity, while the vertical axis along the centre of the quadrilateral helps illustrate the central vowels, for which the tongue body moves upwards.

Debate lies in the symbols used in the IPA system to symbolise central vowels, especially the low central vowel, following the 1989 Kiel convention, during which symbols only for the non-close central vowels were maintained, ignoring the close-mid and open-mid features (Catford, 1990). Central vowels appear problematic in that although they can usually be described using the front/ back dimension this description might not be entirely accurate as productions may vary across the horizontal axis (Spencer, 1996).

The lack of adequate symbolic representation for a low central vowel in the IPA system also has implications for the description of one of the vowels in SMG, due to the organisation of the entire system, which is mentioned as one of a "triangular" form (for instance, Mackridge, 1985; 2010; Papakyritsis & Granese, 2013), which suggests the existence of a low central vowel. According to Maddieson (1984), the most prevalent observation regarding vowel systems of the world's languages is that they are of a triangular form and that within them there are "low vowels [which] are usually central (75.1%) and central vowels [which] are usually low

(69.4%)", increasing the probability of a low vowel which is also central existing in SMG. The vowel in the centre of the quadrilateral and towards the bottom has been symbolised in several ways (/ɐ/, /ɑː/ and /a/), as seen in earlier sections, leading to lack of clarity in terms of its description. Following controversy as to whether a separate symbol should exist for low central vowels in IPA (Barry & Trouvain, 2008; Catford, 1990; Recasens, 2009; Veloso, 2017), I would argue that in order to conclude on the status of controversial vowels, the phonemic characterisation needs to be complemented with acoustic data, which could offer further insights. Understanding the nature of the central vowel in SMG can have implications for the acquisition of new phonemes in a second/ foreign language for which there is contrast between central vowel categories, such as English (IPA, 2015).

More than 10 years after Arvaniti's (2007) influential study, to our knowledge, the case is similar in terms of how SMG is represented in literature: there have not been any recent studies discussing the acoustic characteristics of SMG vowels, so no robust conclusions have been drawn on the status of specific vowels, such as /a/ and /ɛ/, which have been controversial in the literature. Similarly, the topic of the SMG vowel space is still rather obscure. What has recently been the focus of research on Greek is the study of dialects (*VOCALECT*, Baltazani, Fudos, Kainada, Kappa, Lengeris, Mattheoudakis, Mikros et al., 2003). The dialectal studies though mentioned here have a stronger sociolinguistic background, rather than a phonetic one, so they still have not added any further insights to the acoustics of SMG.

Previously, what has been studied, for instance by Botinis, Fourakis and Hawks (1997) and Hawks and Fourakis (1995), was the perceptual vowel space rather than a production vowel space, from which however, different results are derived. Jongman et al. (1989), drawing from Lindblom (1986) mention that a vowel space can be studied from three different perspectives, each corresponding to a different stage in the communication process. First, what is identified is the articulatory stage, which is based on the possible positions of the jaw, tongue, and lip rounding in preparation of the vocal tract to produce a vowel. Then, they identify the acoustic stage which is related to the distribution of energy in terms of time and frequency. This stage is what encapsulates the actual characteristics of the vowels in terms of tongue height, tongue position, and lip rounding. Finally, Jongman et al. (1989) identify the auditory stage, which is related to the sound being processed by each individual and perceived as a linguistic unit. It is important to study production vowel spaces as they have been found to be narrower to perception vowel spaces: listeners tend to prefer vowels that are hyperarticulated leading to perceptual vowel spaces that are larger and vowels that are found in more extreme positions of the quadrilateral, as identified by Lengeris (2016).

In this study, I will be focusing on the vowel characteristics as they are manifested through the first two perspectives of a vowel space: the articulatory and acoustic, with a focus on how the SMG vowels are represented on the acoustic vowel space, when found in a word-medial and a word-final position in CVCV sequences. To my knowledge, there has not been so far a similar study, looking at the SMG acoustic vowel spaces and more detailed features such as the calculation and assessment of the monophthong distances as well as the surface area of the vowel quadrilateral. Therefore, the current study aims at increasing our understanding on the acoustic characteristics of the SMG vowels, by using data from native speakers of the variety, who participated in a production experiment and their data was analysed using contemporary methodology.

2.1.3 Phenomena observed with the Standard Modern Greek vowels

After presenting what previous studies have reported on the status of the SMG vowel system and identifying some reasons leading to controversy on the status of specific vowels, which motivated the current study, this study used acoustic measures to evaluate the status of the vowels and their position on the acoustic vowel space. Although primarily a phonetic study on vowels produced in a controlled environment, it is worth discussing some phenomena that are related to the productions of the Greek vowels, dependent on their position on a word and whether they are stressed or not. Although rare, since those phenomena exist, it important that the are mentioned in this section, before presenting the study conducted.

Allophones

I will first be addressing allophonic variation, which is identified with the high front and back vowels /i/ and /u/ who are realised as consonants in some contexts. Specifically, /u/ becomes /w/ when it is unstressed and preceded by a vowel, like in the case of/ˈfrɐwlɐ/ (“strawberry”) (Arvaniti, 2007). The allophones of /i/ are /j/ or /ç/ through palatalisation when the vowel is a syllable nucleus but is found between a labial (/p/, /b/, /f/, /v/, /m/, /n/) or coronal obstruent (/s/, /z/, /ð/, /θ/, /d/, /t/) and a vowel depending on the voicing of the previous consonant (Arvaniti, 2007). Some examples that apply to this rule are: /ˈhɐpçɐ/ (pills), /ˈkɐbɟɐ/ (caterpillar), /moˈlivɟɐ/ (pencils), /kɐrˈfccɐ/ (nails), /kɐˈlɐmɟɐ/ (reeds), /ˈbɐŋɟɐ/ (baths), /mɐɣɐˈzɟɐ/ (shops), /ˈhɐðɟɐ/ (strokes), /kɐˈlɐθçɐ/ (baskets), /ɐrhoˈdɟɐ/ (nobility), /ɐˈlɐtçɐ/ (salts). Drawing from Arvaniti (2007) again, the allophones /j/ and /ç/ occur when /i/ is unstressed and followed by a vowel, most frequently /ɐ/. However, it should be mentioned here that occurrences such as /pɛðiˈɐ/ (children) when /i/ is produced instead of its allophone have archaic origins and are rare, if not disused completely in modern Greek.

Diphthongs

Following allophonic variation of individual vowels, it is worth mentioning here another topic related to SMG vowels, that of diphthongs, or I as I am choosing to refer to them, “consecutive vowels”, although diphthongs are not the focus of this

Thesis. I am referring to diphthongs as “consecutive vowels” due to controversy on their status, both in terms of their definition and existing examples in the literature. For instance, Holton et al. (1997) consider diphthongs as the primary source of hiatus realisation: the existence of two adjacent vowels in a word. However, instances like /ɐi/, /ɛi/, /ɐu/ and /ɛu/ in more archaic versions of the language have been reduced to /ɐ/, /ɛ/, /ɐf/ and /ɛv/ in SMG. Equally, examples like /uo/, /iɐ/ and /ɐi/ when the first vowel is stressed have been mentioned as diphthongs by Holton et al. (1997), however, I would argue that with the first vowel being stressed the two vowels would be found in separate syllables, hence should be classified as monophthongs.

The idea that adjacent vowels need to be within the same syllable to classify as diphthongs is mentioned in Triantafyllides (1941), a definition though that does not take into account syllabic vowels; vowels that although adjacent, belong in two different syllables. Rare exceptions to the rule are sequences such as /ɐi/ (as in /nɛrˈɐiðɐ/ [fairy]) and /oi/ (as in /ˈroiði/ [pomegranate, colloquial]), for which the vowels are produced separately, through diaeresis, although found in the same syllable. Some more examples in Triantafyllides (1941) (and later in Holton et al., 1997) include sequences like ‘αυ’ and ‘ευ’ , which take into account orthographic rules, rather than phonological (as the previous are pronounced /ɐv/ and /ɛv/ or /ɐf/ and /ɛf/), which suggests lack of clarity as to what constitutes a diphthong in SMG and whether consecutive vowels can indeed be characterised as diphthongs.

Finally, Holton et al. (1997) identifies an alternative method of diphthongisation: sequences comprising any vowel adjacent to the non-syllabic /j/ (or most frequently, especially word-medially /ʝ/) and /w/, considering them allophones of /i/ and /u/ respectively. I would argue though that the insertion of glides constitutes hiatus resolution, which does not necessarily contribute to diphthongisation, since producing the previous allophones is optional. In case the semivowels /j/

and /w/ are not opted for, and their syllabic vowel allophones are used instead, the two adjacent vowels are split during syllabification, so they are realised as two distinct vowels. However, even glide insertion between two adjacent vowels either within the same word or between two words, the first ending with a vowel and the second beginning with one is not a frequent phenomenon in SMG (Baltazani, 2006). In her study the phenomenon appeared to be applied in only 30% by Greek speakers, instead, vowel deletion was preferred. From those accounts on diphthongs it can be observed that there is no clear definition or consistent rules in which vowel sequences, if any, could be considered diphthongs in SMG, therefore, more concrete studies need to be conducted.

Vowel Deletion

As I reported in the previous section, a more common way of hiatus resolution in SMG is by vowel deletion and not by creating diphthongs/ inserting glides (for instance, acknowledged by Baltazani, 2006; Holton et al., 1997). Although frequent, vowel deletion is most common in casual speech and informal settings, therefore not preferred in academic writing or other formal spoken and written situations. Vowel deletion can be observed both word-medially, between morphemes in compound words, as well as between words. Generally speaking, there are no specific rules governing the phenomenon, in that it is hard to predict which vowel gets deleted every time, as it is frequent for both the vowel found in the final position of a word and the first of the next one to be deleted. Vowel deletion between word boundaries is often dependent on the vowels themselves as the least sonorous tends to be deleted, but also on the syntactic relationship between the carrier words.

For instance, the vowel of a weak pronoun before a verb beginning with a vowel gets deleted (some examples include: [tɐ ˈipɐ] > [ˈtɐpɐ] (“I said them [those things]”), [mu ˈɐrɛsɛ] > [ˈmɐrɛsɛ] (“I liked s/he/it”)). Other instances include deletion within compound words comprising a prepositional prefix, in which case the vowel of the prefix gets deleted and compounding occurs (some examples are: [pɐrɐ-ˈɛðosɐ] > [pɐˈrɛðosɐ] ("I delivered"), [kɐtɐ-ˈɛxo] > [kɐˈtɛxo] ("I possess") and so on). Similar observations apply to the neuter singular ([to]) and plural ([tɐ]) articles before nouns, in which case the vowel of the article gets deleted (for instance: [to ɐvˈɣo] ("the egg") > [tɐvˈɣo], [tɐ ɐftoˈkinitɐ] ("the cars") > [tɐftoˈkinitɐ]), prepositions such as [sɛ] ("in/ at") and [ɐˈpo] ("from"), and optionally [ˈmɛsɐ] ("inside") followed by nouns ([sɛ ɛfˈθiɐ] ("in a straight manner [to describe type of movement]) > [sɛfˈθiɐ], [ɐˈpo tɐ vuˈnɐ] ("[originating] from the mountains) > [ɐp tɐ vuˈnɐ], and [ˈmɛsɐ sto ˈspiti] ("inside the house") > [mɛs sto ˈspiti]), imperatives such as the final /ɛ/ of a singular imperative verb, if followed by a weak pronoun beginning with /t/ ([ˈðosɛ to] > [ˈðosto] ("give it (to me)")) or a plural imperative, before /s, l, r/ of the following pronoun ([ˈpɐrɛ tɐ] ("take them") > [ˈpɐrtɐ], which also results in compounding). Another instance of vowel deletion is the unstressed initial /ɛ/ of the adverbs [ɛˈðo] ("here") and [ɛˈki] ("there"), if the preceding word ends in a vowel (examples such as are possible: [ˈfɛrtɐ ɛˈðo] ("bring these [things] here") > [ˈfɛrtɐˌðo] and [ˈpɐmɛ ɛˈki] ("let's go there") > [ˈpɐmɛˌki].

Position and Length

The next topic to discuss regarding SMG vowels is that of vowel positions in words and vowel length. Starting with word position, any of the five vowels may occur both word-initially and word-finally. To exemplify, words such as /ˈɛfɐɣɐ/ (I ate), /ˈpiɣɛnɛ/ (Go!), /ˈɐloɣo/ (horse), /ˈɣriɣorɐ/ (fast), /ˈirɛmos/ (calm; adj., masc.), /piˈɣi/ (fountain), /ˈomorfos/ (beautiful; adj., masc.), /nɛˈro/ (water), /urɐˈnos/ (sky), /miˈkru/ (small; adj., genitive) are part of the Greek word inventory. In fact, the most common observation is a final open syllable (Holton et al., 1997) apart from syllables ending in any of the only two word-final consonants: /s/, or (more rarely) /n/. Apart from vowels being placed anywhere within a Greek word, all vowels can also be combined, forming sequences of two or even three vowels.

Examples of this include words such as the following, for two adjacent vowels:

- /ɛɐ/, as in /ˈnɛɐ/ (young; adj., sing., fem., nominative), /ɛi/, as in /ˈlɛi/ (s/he says), /ɛo/, as in /nɛˈotitɐ/ (youth), /ɛɛ/, as in oˈrɛɛ (beautiful; adj., sing., masc., ablative), and /ɛu/, as in /spuˈðɛu/ (important; adj., sing., masc., genitive).

- ɐɛ/, as in /ɐˈɛnɐos/ (non-stop; adj., sing., masc., nominative), /ɐi/, as in /ɐˈititos/, /ɐo/, as in /nɐˈos/ (temple), /ɐɐ/, as in /isɐˈɐk/ (Isaac), and /ɐu/ as in /ˈflɐuto/ (flute).

- /iɐ/, as in /kiˈɐnos/ (cyan; adj., sing., masc., nominative), /iɛ/, as in /iɛˈrɛɐs/ (priest), /io/, as in /iˈonio/ (Ionian [Sea]), /ii/, as in /iioθɛˈsiɐ/ (adoption), and /iu/, as in /iˈunios/ (June).

- /oɛ/, as in /mikroɛgɛfɐliˈko/ (“mini-stroke”), /oɐ/, as in /oˈɐrio/ (ovary), /oi/, as in /pɐrɐˈnoisɐ/ (I misunderstood), /oo/, as in /ɐɣnoˈo/ (ignore), and /ou/, as in /kɐtɐnoˈun/ (they comprehend).

- /uɛ/, as in /iˈpɐkuɛ/ (obedient; adj., sing., masc., ablative), /uɐ/, as in /iˈpɐkuɐ/ (obediently), /ui/, as in /iisuˈitis/ (Jesuit), /uo/, as in /vɐrjɐˈkuo/ (be hard at hearing), and /uu/, as in /iˈpɐkuu/ (obedient; adj., sing., masc., genitive).

Examples of three adjacent vowels, through compounding are, for instance:

- /ɛoɛ/, as in /nɛoˈɛlinɐs/ (/ˈnɛos/ and /ˈɛlinɐs/; Modern Greek, adj., sing., masc.)

- /ioɐ/, as in /notioɐnɐtoliˈkos/ (/ˈnotios/ and /ɐnɐtoliˈkos/; South-East, adj., sing., masc.).

As I demonstrated, Greek vowels may appear in any position within words and combined with any other Greek vowel to form new words. The last topic to be addressed is that of vowel length. According to Joseph and Tserdanelis (2003) and Newton (1972), vowel length is not contrastive in SMG. All vowels appear to have the same length, unlike what was the case in Ancient Greek when both short and long vowels existed. Joseph and Philippaki-Warburton (1987) though point out that all vowels appear “slightly longer” when stressed, a finding also confirmed by Dauer (1980), who, having performed an acoustic study on Greek vowels, states that although the formant frequencies do not differ significantly between stressed and unstressed vowels, the vowels found in stressed syllables are longer and have higher intensity than those found in unstressed syllables. Holton et al., (1997) also confirm the previous claim, by mentioning that there is a slight vowel weakening in unstressed syllables, unless a vowel is both unstressed and in a word-final position, when it might appear both shorter and slightly devoiced. Examples of this claim can be viewed in the following words: /ˈniki/ (“victory”) against /pɛˈðiɐ/ (“education”). Arvaniti (2000) though, attributes the difference between stressed and unstressed syllables purely to intensity and not duration, claiming that stressed vowels have higher intensity to unstressed ones. Once again, no universal consensus exists regarding the duration of SMG vowels, with both intensity and length put forward as potential characteristics.

So far, I have addressed a number of issues regarding Greek vowels. Beginning with the history and development of the system, I then addressed how vowels have been described in previous and the implications of those descriptions for our understanding of the system. For instance, through presenting what past accounts have demonstrated for the characteristics of SMG vowels, a number of issues were noted, the most important being a degree of inconsistency and controversy on the characteristics of some vowels. I argued that such inconsistencies could be attributed to methodological issues, such as lack of enough analysable tokens either due to a limited number of repetitions or due to limited number of participants. Another possibility is the fact that the IPA system does not account adequately for central vowels, so a lack of consensus on describing the characteristics of the

Greek low central vowel and presenting it symbolically could be due to the lack of existing IPA symbols to do so. Next, I presented a number of phenomena relevant to Greek vowels in order to gain a better understanding of the system as a whole. One of the issues raised, was the lack of consensus on the existence of diphthongs in Greek, due to the variety of definitions and examples already present in past literature. Finally, I discussed topics such as hiatus resolution and vowel deletion as well as vowel length. A number of these topics will be considered in this paper and some further insights will be given. The first topic this paper will focus on is an up-to-date acoustic description of the SMG vowels in order to clarify the controversy existing in the literature so far. The second topic to be discussed is that of vowel length and whether this is a feature of SMG vowels as well as what it is dependent on. I am going to address those topics by conducting an acoustic study on SMG vowels and analysing those findings.

2.2 Methodology

Following an overview of the SMG vowel system according to previous accounts, I conducted an acoustic study in order to address the topics of vowel characteristics and vowel duration. At this instance, I only tested monophthongs, so only the 5 vowels were examined and not any vowel sequences. The details of the study can be found in the following sections.

2.2.1 Participants

19 native Greek speakers (10 males, 9 females, aged 27.2, SD = 5.2, from 21 to 40 years) took part in this study, the majority of whom originated from mainland Greece. Specifically, 12 of them were from Athens, Greece, 6 from the second largest Greek city, Thessaloniki, situated in the north, and 1 from Crete, but were all residing in Colchester, Essex at the time of testing and had been living there for at least 3 years prior to testing. This sample was chosen for two reasons: first,

it would be difficult to locate monolingual SMG speakers with no knowledge or exposure to other languages, as L2 learning is promoted in Greece and Greeks, to some level, have exposure to other languages, either from school, media, tourism, or immigration. Second, by using this participant group, I would be able to compare the productions of SMG and English vowels in a subsequent study (reported in Chapter 4).

To assess the participants' language background and self-assessed confidence levels for the languages spoken, I used two language background questionnaires: the Language History Questionnaire (LHQ), adapted from Li, Sepanski and Zhao (2006) and Li, Zhang, Tsai and Puls, (2014) and the Language Experience and Proficiency Questionnaire (LEAP-Q), adapted from Marian, Blumenfeld, and Kaushanskaya (2007). Both questionnaires recorded biographical information in the beginning, such as gender, age, level of education, and socio-economic status, while the second and more extended parts included questions related to the participants' language background: how many and which languages they spoke, exposure and usage of each language, confidence of each language in the different skills outlined earlier, extended stays in foreign countries and so on. Although the questionnaires were mainly intended to evaluate participants' second language and bilingual experience for the studies presented in the remaining papers of this thesis (Chapters 3 and 4), the participant responses reported in this study provided some insights on the status, usage, and confidence levels of their L1, SMG, which is the focus of this paper.

Based on the responses received from the questionnaires, all participants reported to be using the SMG pronunciation. This was expected not only for those originating from Athens, where SMG is the dominant variety, used in all instances of communication, but also for those who originated from regions outside of Athens. The case was such because not only did they all grow up in large urban centres and were exposed to SMG in their daily lives, schooling, and further Education (if received in Greece), but also because no one self-reported dialectal influences in their speech in the language background questionnaires. Although the participants were tested in the UK, where they were residing when they took part in the study, they were using SMG on a daily basis, as per Tables **??** and **??**. They reported doing so either by communicating with friends and family, and/ or by following Greek media and watching programmes in Greek, therefore they identified themselves as being fully confident (5 out of 5 in self-evaluation Likert scales) in all modes of using Greek (speaking, listening and understanding, reading, and writing). I would therefore consider them as good examples of native Greek speakers.

Apart from Greek, to which all participants were native, they were all second language learners of English (henceforth L2 Learners) too. All participants self-reported a high proficiency in English; they were first exposed to the language in Greece after age 5 and were instructed by Greek teachers of English, also L2 speakers of the language. The participants received additional exposure to English at a naturalistic setting this time, by having lived in the UK for at least 3 years prior to testing. All participants were students in various stages of their degree (Undergraduate or Postgraduate) or members of staff at the University of Essex when tested. In terms of English proficiency, they self-evaluated themselves as being proficient in English due to the years of second language education received (M = 8 years, SD = 1.5), especially in the receptive skills (reading and listening comprehension). Apart from Greek and English, some of the participants reported exposure to other languages, which was limited and to which they were not confident at. The participant profiles can be viewed in Tables **??** for L1, **??** for L2, and Appendix **??** for L3.

Participant No	Gender	Age	Place & Country of Birth	Years in Greece	Years in the UK	Years of English exposure in Greece	Years of English exposure in UK	L1	Percentage of daily usage of L1
11	F	24	Athens, Greece	21	3	10	3	Greek	20%
21	M	23	Heraklion, Greece	20	3	8	3	Greek	30%
22	F	24	Athens, Greece	20	4	9	4	Greek	60%
23	F	28	Athens, Greece	23	5	13	5	Greek	40%
24	M	21	Athens, Greece	17	4	12	4	Greek	55%
25	M	28	Athens, Greece	25	3	11	3	Greek	30%
27	M	24	Athens, Greece	20	4	8	4	Greek	60%
27	M	22	Athens, Greece	19	3	10	3	Greek	40%
29	F	28	Athens, Greece	21	7	11	7	Greek	20%
32	M	29	Athens, Greece	23	3	10	3	Greek	10%
35	F	40	Athens, Greece	22	17	10	17	Greek	15%
36	F	25	Thessaloniki, Greece	22	3	10	3	Greek	20%
38	F	38	Thessaloniki, Greece	22	3	10	3	Greek	60%
49	M	28	Thessaloniki, Greece	24	3	8	3	Greek	30%
50	F	24	Thessaloniki, Greece	20	4	7	4	Greek	30%

Participant No	Gender	Age	Place & Country of Birth	Years in Greece	Years in the UK	Years of English exposure in Greece	Years of English exposure in UK	L1	Percentage of daily usage of L1
51	M	36	Thessaloniki, Greece	27	9	15	9	Greek	20%
53	F	25	Athens, Greece	20	5	11	5	Greek	50%
54	M	27	Thessaloniki, Greece	23	4	8	4	Greek	40%
55	M	24	Athens, Greece	21	3	15	4	Greek	60%

Table 2.1: *L1 background information of Greek adults*

Participant No	L2	L2 Age of first exposure	L2 Age of first exposure to Listening	L2 Age of first exposure to Reading	L2 Age of first exposure to Speaking	L2 Age of first exposure to Writing	Percentage of daily usage of L2
11	English	7	7	7	7	7	80%
21	English	8	8	8	8	8	70%
22	English	7	7	7	7	7	40%
23	English	7	7	7	7	7	60%
24	English	5	5	5	5	5	45%
25	English	5	5	5	5	5	70%

Participant No	L2	L2 Age of first exposure	L2 Age of first exposure to Listening	L2 Age of first exposure to Reading	L2 Age of first exposure to Speaking	L2 Age of first exposure to Writing	Percentage of daily usage of L2
27	English	7	7	7	7	7	40%
27	English	7	7	7	7	7	60%
29	English	6	6	6	6	6	80%
32	English	8	8	8	8	8	90%
35	English	10	10	10	10	10	85%
36	English	8	8	8	8	8	80%
38	English	8	8	8	8	8	40%
49	English	8	8	8	8	8	70%
50	English	7	7	7	7	7	70%
51	English	5	5	5	5	5	80%
53	English	9	9	9	9	9	50%
54	English	8	8	8	8	8	60%
55	English	6	6	6	6	6	40%

Table 2.2: *L2 background information of Greek adults*

2.2.2 Materials and Procedure

For the purposes of the task, the five SMG vowels were embedded in carrier frames of the format /pVpV/, which were in turn embedded in carrier phrases. The participants were asked to produce the following phrases, adapted from Lengeris (2016):

‘Δε ϑα πω π*V*π*V* πουϑενά.’ /ðε θɐ po pVpV puθεˈnɐ./

[“I will not say /pVpV/ nowhere (lit. anywhere)”.]

‘Τι δε ϑα πεις πουϑενά;’ /Ti ðε θɐ pis puθεˈnɐ?/

[What are you not going to say nowhere (lit. anywhere)?]

‘Δε ϑα πω π*V*π*V* πουϑενά.’ /ðε θɐ po pVpV puθεˈnɐ./

[“I will not say /pVpV/ nowhere (lit. anywhere)”.]

Overall, a total of 380 vowel tokens was obtained (19 speakers x 5 vowels x 4 repetitions [2 in the medial and 2 in the final position)]. Stress was not applied explicitly to any vowel in either side of the consonant frame and the sequences generated were (mostly) nonsense words in Greek, as per Table **??**.

Table 2.3: *List of tokens used in the production task*

Tokens	Real word	Comment	Nonsense word
pipi	✓	/piˈpi/ (*urine*, informal; used in child-directed speech)	N/A
pepe	N/A	N/A	✓
papa	✓	/pɐˈpɐ/ (*priest*, vocative)	N/A
popo	✓	/poˈpo/ (*rear side*, informal; vocative)	N/A
pupu	N/A	N/A	✓

The participants were asked to read aloud the sentences presented to them on paper, and were encouraged to do so by using their regular voices, in a neutral manner and without emphasising any of the words or trying to “act them out”. I gave these instructions in an attempt to encourage neutral productions, without participants hyperarticulating specific words/ segments (Lengeris, 2016), as well as productions carried out in a neutral tempo, neither fast nor slow, contrary to the study of Fourakis et al. (1999), who opted for both tempo conditions. However, due to the fact that in SMG stress is applied to one of the three final syllables (Mackridge, 1985, among others), I cannot exclude the possibility that participants unconsciously applied stress to the final vowel.

A Sennheiser MD42 omnidirectional microphone was mounted on a table base and placed in front of the participant's mouth at a 10cm distance. The microphone was connected to a Behringer Xenyx 502 Analogue Mixer preamp with a 3-pin XLR cable which was also connected to a MacBook Pro Laptop with Praat installed (Boersma & Weenink, 2006). The recordings were performed in a quiet room in the Department of Language and Linguistics, University of Essex and were done directly in Praat at a 44.1 kHz sampling rate and 16-bit quantisation.

I opted for the /pVpV/ frame as it was necessary to provide a controlled vowel environment in order to avoid co-articulation effects and maintain experimental control (Bouferroum & Boudraa, 2015). Jongman et al. (1989), for instance, identify co-articulation effects as one of the main factors affecting the acoustic characteristics of the vowels, which called for a neutral environment in order to obtain as accurate measures as possible. Other similarly neutral environments include sequences such as /sVs/, used in the study of the vowel systems of Standard Dutch spoken in the Netherlands and Standard Dutch spoken in Flanders by Adank, Van Hout and Velde (2007). Alternatively, Clopper, Pisoni and De Jong (2005) in their study of acoustical characteristics of American English vowels of six regional varieties chose to insert the English vowels in vocalic environments of the format /hVd/. I decided to incorporate the vowels in frames where the consonant would be kept constant on either side, hence avoided the choice of the /hVd/ frame. In order to achieve as neutral enunciation as possible, I also used a vocalic environment that would help generate nonsense Greek words as much as possible. By using the /sVs/ fame, some real words could be generated (/soˈso/, /ˈsisi/, /ˈsɐsɐ/, all versions of female names), which might have affected the sequence production by applying stress.

2.2.3 Acoustic Measures

Formant Frequencies

After the recordings were conducted, the /pVpV/ sequences were isolated and manually extracted in Praat (Boersma & Weenink, 2006), followed by an identification and labelling of the individual vowels using the TextGrid annotation function and simultaneous visual inspection of the spectrogram and waveforms (Grijalva, Piccini & Arvaniti, 2013). The boundaries were placed at the midpoint of the stable part of each vowel using a 0.04s window. Following this, formant measurements (F_1, associated with the tongue height: high versus low and F_2, associated with tongue position: front versus back; Stephens, 1998) were automatically retrieved by making use of a Praat script, developed to measure at the 25%, 50%, and 75% of the selected window (measures used, for instance, in Lengeris, 2006, and Themistocleous, 2017, among others). After the script output was obtained, an average of the 3 measurements was taken and used for data processing and analysis, following normalisation.

Vowel formant frequencies were normalised using the online tool *NORM Vowel Normalisation and Plotting Suite* provided by Thomas and Kendall (2007). The chosen normalisation procedure followed the Neary-2 method (Neary, 1978), as described in Adank, Smits and Van Hout (2004) and Adank et al. (2007). As the Neary-2 method does not yield Hertz values, the output was converted to Hertz-like values, using the formulae:

$$F_1 = 250 + 500(F_1^N - F_{1MIN}^N)/F_{1MAX}^N - F_{1MIN}^N) \tag{2.1}$$

and

$$F_2 = 850 + 1400(F_2^N - F_{2MIN}^N)/(F_{2MAX}^N - F_{2MIN}^N) \tag{2.2}$$

Normalisation was used to permit comparison between genders to avoid differences between male and female participants' frequencies (Peterson and Barney, 1952).

Vowel space

After the identification and extraction of the frequencies of the first two formants ($F_1$and F_2) and subsequent normalisation, two different production vowel spaces for all the participants were calculated, one for the vowels in the medial position and one for the vowels in the final position. The comparison of the two vowel spaces was used to measure potential differences in the size of the acoustic space depending on the vowels' position in an consonantal environment, as previous accounts have suggested (for instance, Fourakis et al., 1999 observed vowel fronting and larger vowel spaces for stressed vowels, as was the case in the findings of Baltazani (2007) and Themistocleous (2017), amongst others, for the expansion of the vowel space).

The vowel space area was measured in two ways: first, the area per condition (medial and final) was divided into three triangles and the area of each triangle was calculated using Heron's formula and summing the triangles, as per the methodology adopted by Lengeris (2016) and others (Bunton & Leddy, 2011; Sapir, Ramig, Spielman, & Fox, 2010). The area calculation was performed using the following formula:

$$\sqrt{S(S-A)(S-B)(S-C)} \tag{2.3}$$

where S is the semi-perimeter of the triangle and A, B, C are the three sides. The semi-perimeter was calculated with the formula:

$$S = \frac{A+B+C}{2} \tag{2.4}$$

The second method calculated the area of the entire polygon as defined by the mean values for each vowel and was computed automatically in R, using the package *phonR* (McCloy, 2016). In both cases, the measurement unit of the vowel space area was Equal Rectangular Bandwidth (ERB^2) (Glasberg & Moore, 1990)

Euclidian distance

Apart from the area of the acoustic vowel space, what also needed to be calculated was the Euclidian distance between the vowels, in order to quantify any degree of assimilation. As Baltazani (2006) proposes, smaller distance among certain vowels would suggest a higher degree of assimilation. The Euclidian distance of the first two formants was calculated with the following formula:

$$\sqrt{(F_{1nuc} - F_{1off})^2 + (F_{2nuc} - F_{2off})^2} \tag{2.5}$$

where F_1 is the first formant, F_2 the second, *off* is the measurement at the 75% of the vowel (offglide), subtracted by *nuc*, the measurement at the 25%.

Duration

Another measure of interest was vowel duration. Measures at the start and end of the marked vowels were obtained automatically with the Praat script used to extract the formant frequencies. The duration interval was then computed by subtracting the measurement at the end of the annotated vowel from that at the beginning.

Intensity

The final measure was vowel intensity, also obtained automatically with the script used to measure formant frequencies and duration. Average intensity was computed by using the intensity measures at the beginning and end of the annotated vowels, then taking the average of the two values in dB.

2.3 Results

Following the identification and labelling of the individual vowels the following measures were obtained and analysed: (i) vowel duration and (ii) intensity, (iii) the normalised frequencies of the first two formants ($F_1$and F_2), (iv) the Euclidian distance between vowels, and (v) the total vowel space area. To explore whether there were significant differences per position for vowel duration, intensity, and formant frequencies linear mixed models were chosen, in order to to account for individual variability. Euclidian distance and the total vowel space areas were calculated by adding the normalised values for F_1 and F_2 in the formulae presented in the previous section. Euclidian distance amongst conditions was compared by means of a linear mixed model and post hoc tests. The total vowel space area was compared by means of Welch's t-tests.

Duration

The first variables to be examined in this study were those of vowel duration, followed by vowel intensity, as according to Dauer (1980) apart from duration the acoustic correlate responsible for the perception of longer vowels is intensity rather than duration. Looking into vowel duration first, it was observed that overall, vowels in the final position were longer than those in the medial position, as it can be viewed in Figure **??** and Table **??**. The open vowels /ɐ/ and /ɛ/ appear to have longer durations, followed by the closed and rounded /u/ and /o/. Finally, the high-front, unrounded /i/ is the shortest of all. In line with the duration measures in the medial position, the open vowels /ɛ/ and /ɐ/ are the longest in the final position too, followed by the closed rounded /u/ and /o/. Once again, the high-front unrounded /i/ has the shortest duration.

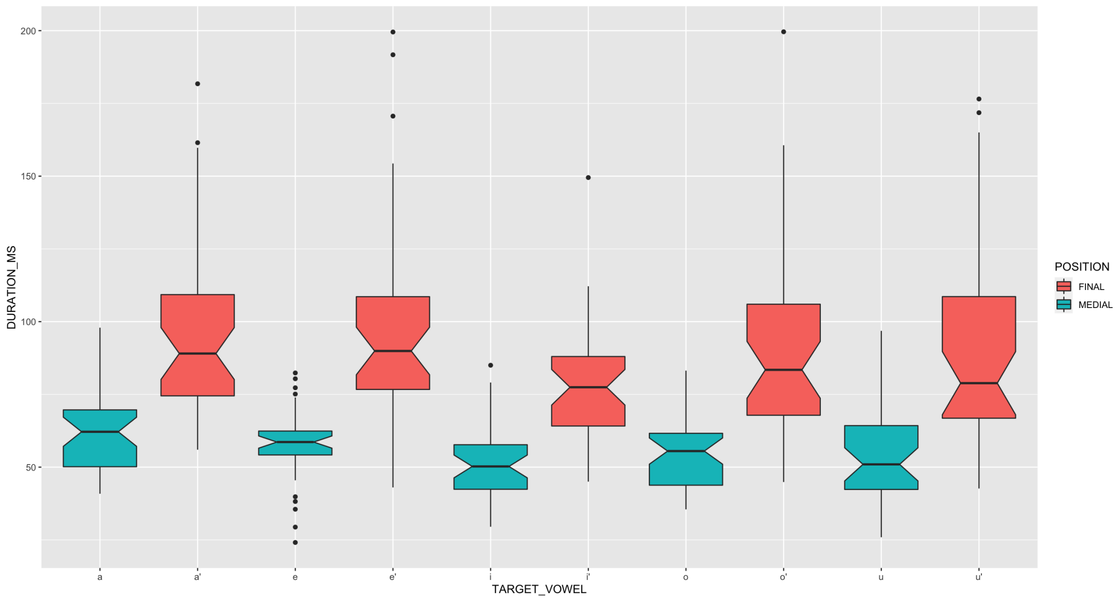


Figure 2.2: Average duration (ms) (DURATION_MS) for target vowels per position in the /pVpV/ frame.

Table 2.4: *Average raw duration values (in ms) and standard deviation (SD) for target vowels per position.*

Vowel	Position	Duration (SD)
ɐ	Medial	61.43 (13.68)
ɐˈ	Final	97.15 (29.89)
ɛ	Medial	57.79 (12.93)
ɛˈ	Final	98.13 (35.42)
i	Medial	50.84 (13.48)
iˈ	Final	76.57 (20.48)
o	Medial	54.67 (12.18)
oˈ	Final	91.52 (31.02)
u	Medial	53.18 (16.34)
uˈ	Final	90.72 (36.00)

Following descriptive statistics and plotting of the vowels, the factor *Duration* was tested for normality both with a histogram and the Shapiro-Wilk test (Shapiro &

Wilk; 1965) and was Log transformed before adding it to a linear mixed effects model, chosen to account for individual variability. The duration model had the factors *Target Vowel* and *Position* in the fixed part, whilst *Participants* and *Response* were the random effects. As per Table **??**, both target vowel and position contributed significantly to the model fit.[3] The vowels which different significantly in duration from the baseline /ɐ/ were /ɐˈ/ ($p < .001$), /ɛˈ/ ($p < .001$), /ɪ/ ($p = .04$), /ɪˈ/ ($p = .03$), /ɔˈ/ ($p < .001$), and /ʊˈ/ ($p < .001$).

Since the phonemic environment (the consonant frame /pVpV/) that the vowels were produced in was controlled for, the surrounding consonants would not influence the duration of the vowels, so the duration differences observed are attributed to their position on the consonant frame.

Table 2.5: *The fixed effects (Target vowel and Position) in the linear mixed model for Duration (ms). The baseline for Target vowel is /ɐ/, and for Position is Medial. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	Duration (LogTransformed) (ms)	
Target Vowel ɐˈ	0.440***	(0.054)
Target Vowel ɛ	−0.066	(0.098)
Target Vowel ɛˈ	0.435***	(0.098)
Target Vowel i	−0.199**	(0.098)
Target Vowel iˈ	0.211**	(0.098)
Target Vowel o	−0.117	(0.098)
Target Vowel ɔˈ	0.378***	(0.098)
Target Vowel u	−0.167*	(0.099)
Target Vowel uˈ	0.345***	(0.099)
Position Final	0.345***	(0.088)
Intercept	4.094***	(0.073)
Observations	379	
Log Likelihood	−28.081	
Akaike Inf. Crit.	82.162	

Intensity

Following duration, vowel intensity was also analysed. Overall, intensity was also higher in the final position, as it can be viewed in Figure **??** and Table **??**.

[3] The model tables in this Thesis were adapted using the package *Stargazer*, developed by Hlavak (2018).

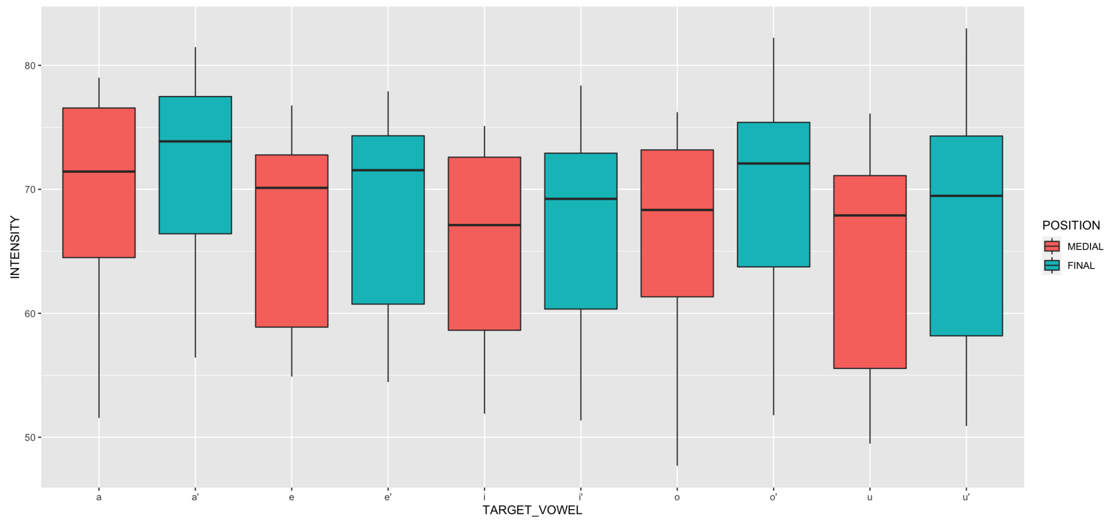


Figure 2.3: Average Intensity (dB) for target vowels per position in the /pVpV/ frame.

Table 2.6: *Average raw intensity values (in dB) and standard deviation (SD) for target vowels per position.*

Vowel	Position	Intensity (SD)
ɐ	Medial	69.91 (7.48)
ɐˈ	Final	72.34 (6.55)
ɛ	Medial	66.90 (7.28)
ɛˈ	Final	68.19 (7.37)
i	Medial	65.74 (7.35)
iˈ	Final	67.11 (7.51)
o	Medial	66.79 (7.87)
oˈ	Final	69.80 (7.66)
u	Medial	64.53 (8.68)
uˈ	Final	66.74 (8.93)

After descriptive statistics, Intensity was also tested for normality with a histogram and the Shapiro-Wilk test (Shapiro & Wilk; 1965) and was Log transformed before adding it to a linear mixed effects model, as below:

$$\textit{logIntensity} \sim \textit{Target Vowel} + \textit{Position} + \textit{(1 | Participant No)} + \textit{(1 | Response)} \quad (2.6)$$

where Target Vowel and Position were the fixed effects and Participant and Response the random effects. The factor target vowel significantly contributed to the model fit ($p < .001$), whilst this was not the case for the factor position, which did not improve the model fit ($p = .55$) as per Table **??** below. When comparing individual vowels to the baseline /ɐ/ though, only /ɐˈ/ differed significantly in terms of intensity ($p < .001$). The findings suggest that regardless their position, the vowels were produced with the same level of intensity.

Table 2.7: *The fixed effects (Target vowel and Position) in the linear mixed model for Intensity (dB). The baseline for Target vowel is /ɐ/, and for Position is Medial. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	Intensity (LogTransformed) (dB)	
Target Vowel ɐˈ	0.036^{***}	(0.011)
Target Vowel ɛ	−0.044	(0.079)
Target Vowel ɛˈ	−0.025	(0.079)
Target Vowel i	−0.062	(0.079)
Target Vowel iˈ	−0.041	(0.079)
Target Vowel o	−0.050	(0.078)
Target Vowel ɔˈ	−0.007	(0.079)
Target Vowel u	−0.081	(0.079)
Target Vowel uˈ	−0.047	(0.079)
Position Final	−0.047	(0.079)
Intercept	4.241^{***}	(0.061)
Observations	379	
Log Likelihood	553.200	
Akaike Inf. Crit.	−1,080.401	

Formant Frequencies

More variables to be explored were those of the first two formants (F_1 and F_2), used to place the vowels on the vowel quadrilateral and reconstruct the $F_1 \times F_2$ acoustic vowel space. By using acoustic measures to place individual vowels on the quadrilateral, I would then be able to draw conclusions on their position and acoustic characteristics, especially addressing the vowels that have been considered of a controversial status in the past. The formant frequency measures were also useful, as following the positioning of the vowels on the acoustic space, the points were connected with vectors which represent the Euclidian distance among the points. Overall, vowels in the final position had higher formant frequency values, as it can be viewed in Tables **??** and **??**.

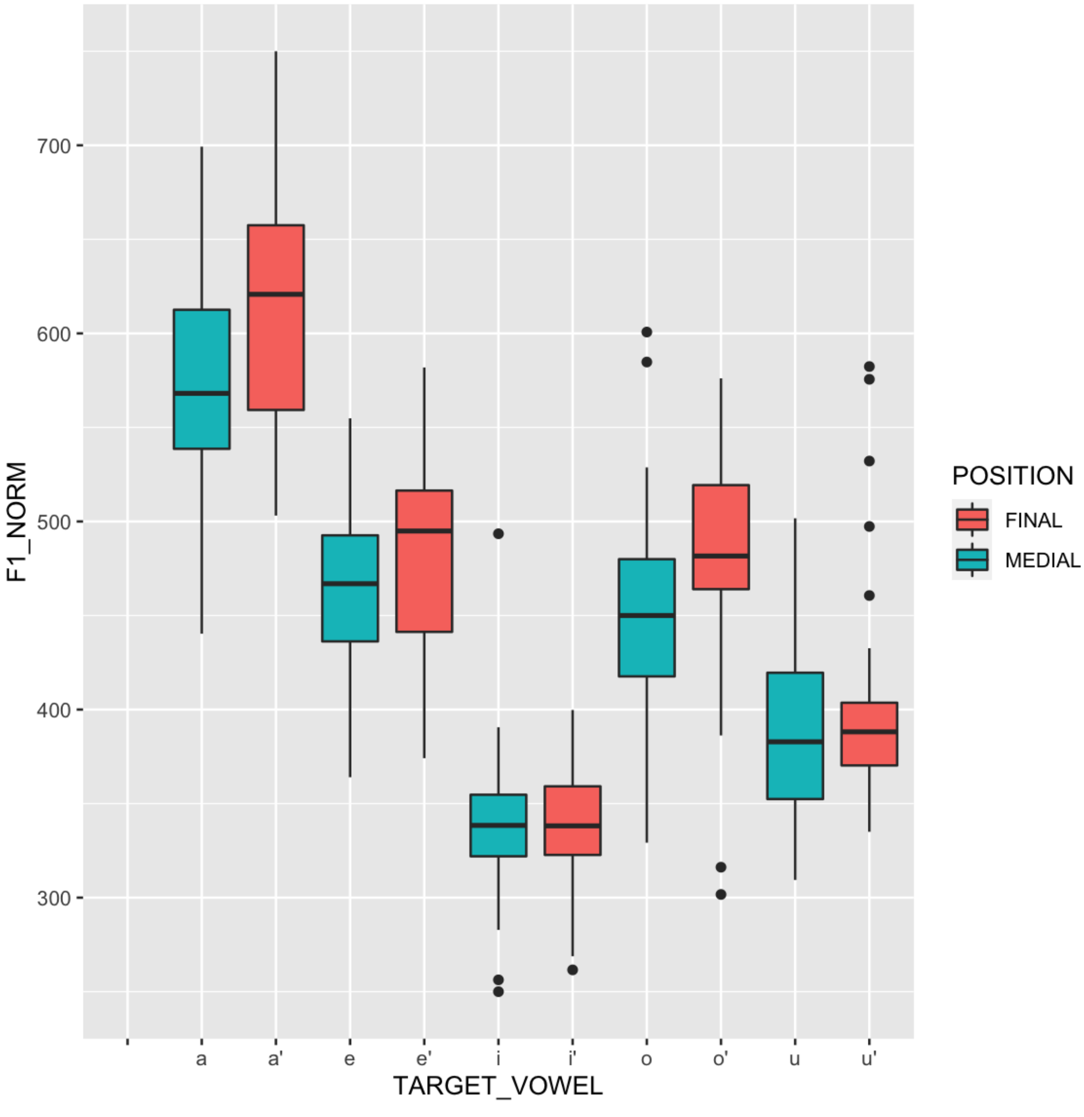


Figure 2.4: Normalised F_1values (Hz) (F_1_NORM) for target vowels per position in the /pVpV/ frame.

Table 2.8: *Normalised F_1 values (in Hz) and standard deviation (SD) for target vowels per position.*

Vowel	Position	F_1 (Hz)
ɐ	Medial	573.87 (54.81)
ɐˈ	Final	612.97 (62.88)
ɛ	Medial	462.70 (46.47)
ɛˈ	Final	482.06 (52.47)
i	Medial	338.76 (40.83)
iˈ	Final	336.67 (32.77)
o	Medial	451.47 (55.78)
oˈ	Final	483.94 (57.42)
u	Medial	389.49 (43.56)
uˈ	Final	401.10 (59.14)

Following descriptive statistics and tests for normality, separate mixed effects models were developed per formant. As the formant frequencies had already been normalised, no log transformation was necessary. Similar to previous models, the *F_1_NORM ~Target Vowel* model included *Target Vowel* and *Position* as fixed effects and *Participant* and *Response* as random effects. However, neither position (p = .22) nor target vowel (p = .31) contributed significantly to the model fit, as it can be viewed in Table **??**, whilst, neither vowel differed significantly from the baseline /ɐ/ in terms of F_1.

Table 2.9: *The fixed effects (Target vowel and Position) in the linear mixed model for F_1 (normalised) (Hz). The baseline for Target vowel is /ɐ/, and for Position is Medial. (“***” p < 0.001, “**” p < 0.01, “*” p < 0.05, “.” p < 0.1, “ ” p < 1)*

	Dependent variable:	
	F_1 (normalised) (Hz)	
Target Vowel ɐˈ	0.065^{***}	(0.025)
Target Vowel ɛ	−0.216	(0.503)
Target Vowel ɛˈ	−0.176	(0.503)
Target Vowel i	−0.529	(0.503)
Target Vowel iˈ	−0.534	(0.503)
Target Vowel o	−0.242	(0.503)
Target Vowel ɔˈ	0.173	(0.503)
Target Vowel u	−0.390	(0.503)
Target Vowel uˈ	−0.364	(0.503)
Position Final	−0.489	(0.401)
Intercept	6.348^{***}	(0.356)
Observations	379	
Log Likelihood	267.199	
Akaike Inf. Crit.	−508.398	

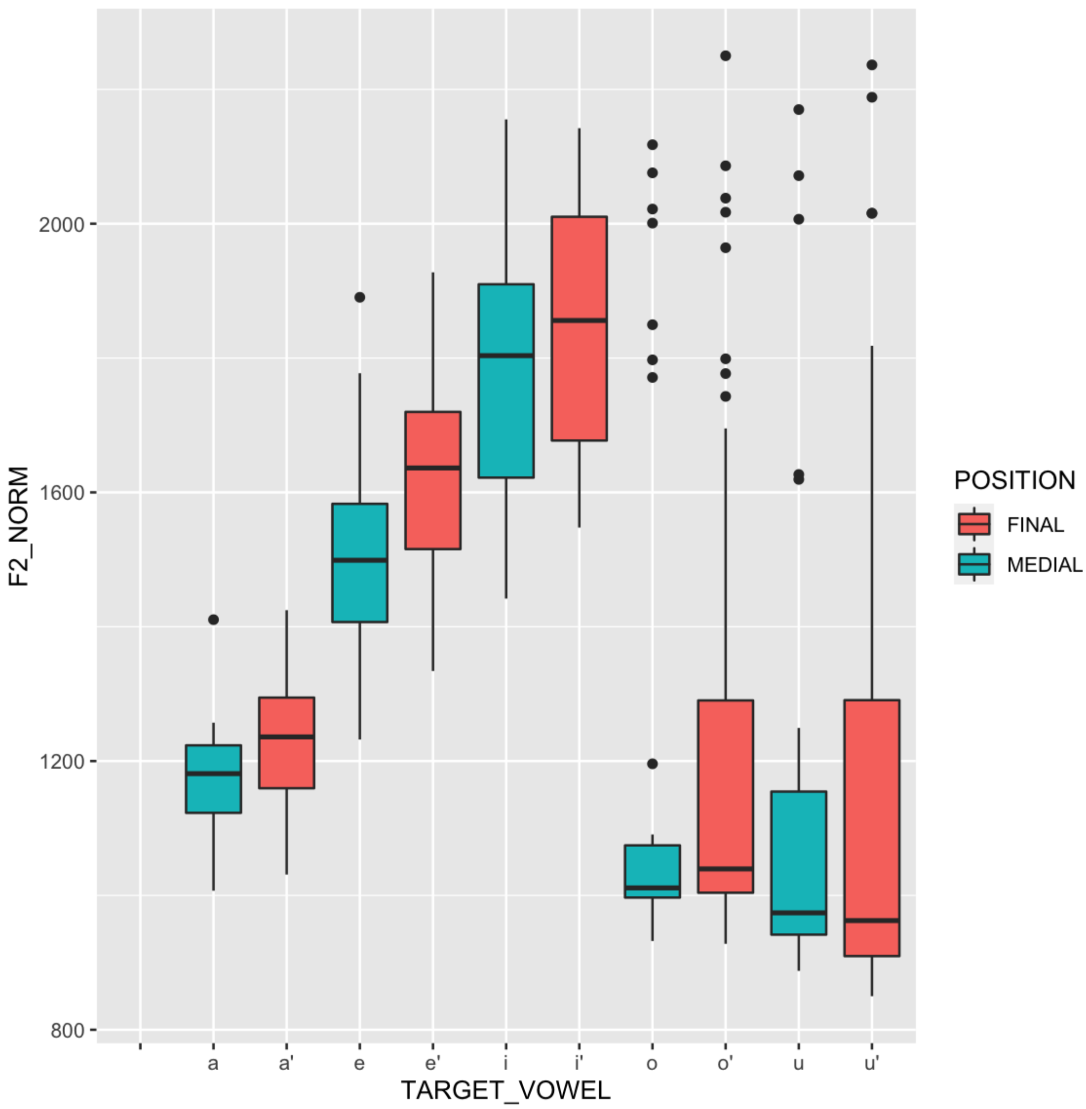


Figure 2.5: Normalised F_2 values (Hz) (F_2_NORM) for target vowels per position in the /pVpV/ frame.

Table 2.10: *Normalised F_2 values (Hz) and standard deviation (SD) for target vowels per position.*

Vowel	Position	Intensity (SD)
ɐ	Medial	1173.30 (76.91)
ɐˈ	Final	1226.79 (96.69)
ɛ	Medial	1505.41 (136.69)
ɛˈ	Final	1625.61 (146.57)
i	Medial	1772.40 (186.37)
iˈ	Final	1848.52 (179.33)
o	Medial	1177.08 (172.06)
oˈ	Final	1241.94 (103.29)
u	Medial	1125.36 (135.51)
uˈ	Final	1169.57 (115.79)

For F_2, the model

$$F_2\_NORM \sim Target\ Vowel + Position + (1 \mid Participant\ No) + (1 \mid Response) \quad (2.7)$$

was used. As per Table **??**, neither position (p = 1) nor target vowel (p = .17) contributed significantly to the model fit, whilst only /i/ (p = .03) and /iˈ/ (p = .02) differed significantly from the baseline /ɐ/ in terms of F_2, suggesting no differences in vowel backness of the vowels depending on their position.

Table 2.11: *The fixed effects (Target vowel and Position) in the linear mixed model for F_2 (normalised) (Hz). The baseline for Target vowel is /ɐ/, and for Position is Medial. ("***" $p < 0.001$, "**" $p < 0.01$, "*" $p < 0.05$, "." $p < 0.1$, " " $p < 1$)*

	Dependent variable:	
	F_2 (normalised) (Hz)	
Target Vowel ɐˈ	0.090	(0.091)
Target Vowel ɛ	0.413	(0.282)
Target Vowel ɛˈ	0.461	(0.282)
Target Vowel i	0.591**	(0.282)
Target Vowel iˈ	0.633**	(0.282)
Target Vowel o	0.188	(0.282)
Target Vowel ɔˈ	0.218	(0.282)
Target Vowel u	0.096	(0.282)
Target Vowel uˈ	0.321	(0.282)
Position Final	−0.489	(0.401)
Intercept	7.126***	(0.199)
Observations	379	
Log Likelihood	−198.709	
Akaike Inf. Crit.	423.418	

As mentioned earlier, the formant frequency measures were used to position the vowels on the $F_1 \times F_2$ acoustic pane, which can be viewed in Figure **??**.

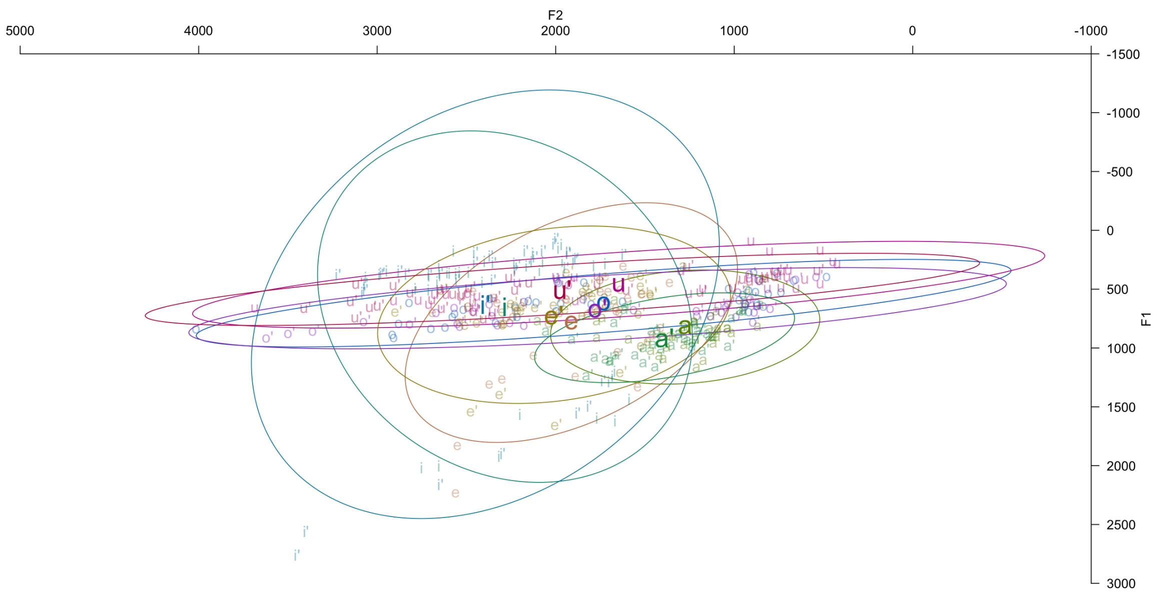


Figure 2.6: Position of the SMG vowels in the $F_1 \times F_2$ acoustic vowel space for the medial and final positions.

Euclidian Distance

After the vowels were plotted on the $F_1 \times F_2$ acoustic space per position (Figure **??**), vectors to connect the vowels were drawn as follows i-ɛ, ɛ-ɐ, ɐ-o, o-u, and u-i and the Euclidian distances among the points were calculated and compared with a linear mixed effects model, for which *Vectors* and *Position* were the fixed effects and *Participants* was the random effect. The average absolute Euclidian distances between vowels in the two positions can be viewed in Table **??**.

Table 2.12: *Absolute distances (in ERBs) among vowels in the medial and focus position*

Vectors	Distance Medial	Distance Final
iɛ	396	394
ɛɐ	639	649
ɐo	499	452
ou	178	253
ui	663	449
iɐ	1024	1043
io	553	628
ɛu	417	221
ɛo	244	250

Following the model output, the factor *Vector* contributed significantly to the model fit ($p < .001$), however, *Position* did not contribute significantly ($p = .07$). The vectors which differed significantly from the baseline ɐo were iɐ ($p < .001$), as well as io ($p = .001$), and ui ($p = .006$) as per Table **??**.

Table 2.13: *The fixed effects (Vector and Position) in the linear mixed model for Euclidian Distance (ERB). The baseline for Vector is* ɐo, *and for Position is Medial. ("***" $p < 0.001$, "**" $p < 0.01$, "*" $p < 0.05$, "." $p < 0.1$, " " $p < 1$)*

	Dependent variable:	
	Euclidian distance (ERBs)	
Vector iɛ	−127.673	(104.512)
Vector ɛɐ	−24.686	(104.512)
Vector ou	4.414	(104.512)
Vector ui	286.400***	(104.512)
Vector iɐ	424.052***	(104.512)
Vector io	334.919***	(104.512)
Vector ɛu	93.275	(104.512)
Vector ɛo	−39.445	(104.512)
Position Final	87.615*	(49.287)
Intercept	7.126***	(0.199)
Observations	342	
Log Likelihood	−2,535.850	
Akaike Inf. Crit.	5,095.700	

Vowel Space Area

The final measure calculated was the total acoustic vowel space for each position (medial and final). The total vowel space area was obtained and calculated in two ways: first, by splitting the vowel quadrilateral in three triangles and calculating the areas of each, before adding the three areas, viewed in Table **??**; second, by calculating the area of the convex hull defined by the values of all vowel tokens in *phonR* (McCloy, 2016).

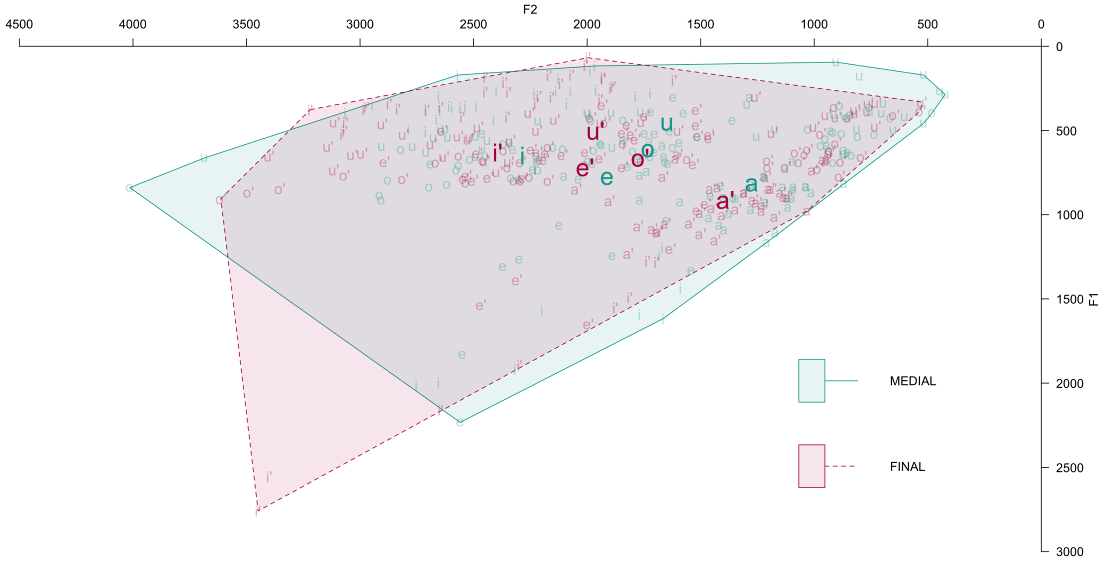


Figure 2.7: $F_1 \times F_2$ acoustic vowel space for the SMG vowels in the medial and final positions.

Table 2.14: *Acoustic vowel space total area (in ERB^2) for vowels in the medial and final position*

Triangles	Area (ERB^2) Medial	Area (ERB^2) Final
iɛu	78098	43563
uɛo	7369	25036
ɛɐo	55983	41150
Total area	141450	109749

Participant No	Area (ERB^2) Medial	Area (ERB^2) Final
21	829800.5	964420.50
22	1172742.0	1140217.50
23	569403.5	521451.0
24	1330280.0	1017017.00
25	96166.5	1174363.0
26	1332879.0	1218388.50
27	805312.5	970669.5
29	416074.0	577584.0
32	1013083.0	833532.0
35	2169694	2922016
36	984172.00	746344.5
38	681696.0	2194055.5

Participant No	Area (ERB^2) Medial	Area (ERB^2) Final
49	864416	667642
50	692114.0	1140204.5
51	1251824.0	1066329.50
53	856057.5	1015886.0
54	1443798.0	1123949.5
55	671869.0	377058.00
56	863050.0	1546979.0
Average Total area	954445	1016449

Table 2.15: *Total convex hull vowel space total area (in ERB^2) per participant for vowels in the medial and final position*

Using the results of the first method (Table **??**)and by comparing the areas in each condition, it was observed that vowel space area is smaller by 28% when the vowels appear in a final open syllable (141450 ERBs^2 for the medial position and 109749 ERBs^2 for the final position). However, following a two-sample t-test comparing the vowel space areas of all participants in the medial and final condition (Table **??**), no significant differences were found between the areas of the two spaces ($t((31) = -.07323$; $p = .46$).

2.4 Discussion

Following controversy on the status of the SMG vowels, this study aimed at providing up-to-date acoustic descriptions to help understand the status of the Greek monophthongs from a phonetic point of view. For the purposes of the study, I obtained and analysed spectral (F_1, F_2) and temporal (duration) acoustic measures as well as vowel intensity, and vowel distances, from the productions of 19 native Greek speakers. By conducting this study I aimed at addressing the following topics; first, clarity was necessary on the acoustic characteristics of the SMG monophthongs, especially in terms of the low central vowel and the front open-mid vowel, both of which have been described controversially in the literature. By obtaining formant frequency measures and calculating the absolute distances among vowels, I focused on determining the positions of the vowels on the acoustic pane, which would offer insights on their characteristics; I also used the previous measures in an attempt to reconstruct the vowel space area of SMG. The next topic that required clarity was that of vowel duration in SMG, as previous accounts have claimed that there are no short and long vowels in SMG (Joseph & Tserdanelis, 2003; Newton, 1972), while others attributed vowel length to higher intensity (Arvaniti, 2000) or stress (Baltazani, 2007; Dauer, 1980; Holton et al., 1997; Joseph & Philippaki-Warburton, 1987). To determine whether vowel length is a feature in SMG and what it is dependent on, the measures of vowel duration and intensity were obtained and analysed.

Formant Frequencies and Position on the Vowel Quadrilateral

The first topic to be discussed is that of formant frequencies, which were used in the positioning of the vowels on the acoustic space and determining their characteristics. Looking at the vowel space area as a whole, in accordance with Jongman et al. (1989), Hawks and Fourakis (1995), and Fourakis et al. (1999) most vowels both in the medial and in the final position appeared separated in the acoustic vowel space, allowing for some dispersion amongst categories. Regardless of their position in the consonant frame, both vowels in the medial and final position were produced with the same degree of height and backness as neither F_1 (associated with vowel height) nor F_2 values (associated with the degree of frontness/ backness) differed significantly per position.

The acoustic measures of the formant frequencies and subsequent position on the $F_1 \times F_2$ acoustic vowel space for /i/, /o/, and /u/ are in accordance with the observations made in previous acoustic studies on SMG, for instance in Jongman et al. (1989) and Fourakis et al. (1999). The acoustic measures for /i/ permit its placement in the high-front area, while those for /o/ and /u/ place the vowels in the high back area of the space, with /u/ being higher than /o/ which is relatively mid-high and more low, especially in the final position. This allows the characterisation of both vowels as back and rounded. /ɛ/ and /ɐ/ are the two vowels over which there has been controversy on their status, as different phonological accounts have been characterising and transcribing them in different ways. Based on the spectral measures obtained, /ɛ/ was placed in the mid area of the quadrilateral, being produced centralised and having relatively the same degree of height as /o/ at the back of the acoustic pane. The formant frequencies and consequently positions of those two vowels on the $F_1 \times F_2$ vowel space are in line with what previous acoustic studies have found (Fourakis et al., 1999; Jongman et al., 1989). According to the findings of this study, and complementing previous ones, I would characterise /ɛ/ as a mid-open unrounded vowel, as the accounts of Botinis (1981) and Themistocleous (2017) have found previously, both commenting on its centralised quality.

Finally, the formant frequencies and positioning of the vowel /ɐ/ advocate for it being characterised as a low open vowel, which was realised towards the back of the vowel space, therefore, having a more open quality to what Arvaniti (2007), Jongman et al., (1989), and Themistocleous (2017) had found previously and in line with less recent accounts. For instance, the studies of Botinins (1981) and Joseph and Philippaki-Warburton (1987) were finding the vowel at a lower and more back position, which is contrary to the measures of this study. To exemplify, Botinis (1981) had characterised /ɐ/ as being a central vowel placed toward the back of the space, and was was using the /a/ notation, and Joseph and Philippaki-Warburton (1987) were identifying the same vowel as being open and back, so they were using the /ɑː/ transcription. Variability in the findings could be attributed to a number of reasons, for instance, a low number of speakers and usable tokens, as well as the structure of the experimental stimuli (CV sequences that in relation to the adjacent word [/ˈɣrɐpsɛ t[i, ɛ, ɐ, o, u]/], which could have lead to vowel reduction or even deletion) in Botinis (1981) or the descriptive account of Joseph and Philippaki-Warburton (1987).

Vowel distances and total acoustic vowel space

Two more topics that this study addressed was those of absolute vowel distances and overall acoustic vowel space for the SMG vowels in medial and final positions. Both measures were obtained in order to reconstruct the vowel space area of SMG, evaluate whether the vowels are well separated on the space, as well as whether the position of a vowel in a word affects its acoustic characteristics and positioning. As it was confirmed in the statistical analyses, the absolute distances among the vowels in the vowel spaces of the two conditions, did not differ significantly between the final and medial position, with the exception of the distance between /i/ and /o/, /u/ and /i/, and /o/. Therefore, overall, the vowels maintained their positions on the space regardless of whether they were found in the medial or final position of the frame. Although stress was not present in the stimuli used in this study, the fact that my findings are in agreement with what was observed in studies where stress was explicitly applied (Fourakis et al., 1999), might suggest that the vowels in the final position were produced as if they were stressed by the participants, due to the stress pattern of SMG. Although the Euclidian distances were not significantly longer in the final position, the overall vowel space appeared more expanded in the latter condition, by 29%, which was also in line with what Baltazani (2007); Dauer (1980), Fourakis et al. (1999), Kontosopoulos (1981; 2011), Newton (1972), Themistocleous (2017), and Trudgill (2003) have observed: a smaller overall vowel space area and more centralised vowels when those were not stressed.

Duration and Intensity

Another topic that was addressed in this study was that of vowel duration and intensity. As I mentioned previously, past studies on SMG have provided mixed interpretations on what vowel duration might be dependent on. Theoretical and experimental accounts have claimed that vowels might appear longer when stressed (Dauer, 1980; Holton et al., 1997; Joseph and Philippaki-Warburton, 1987) or instead of longer durations, stress affects intensity only (Arvaniti, 2000). Although not explicitly stressed, all vowels in the final position were found to have higher duration but not intensity, as it has been previously identified by Dauer (1980), Fourakis et al. (1999), Holton et al. (1997), and Joseph and Philippaki-Warburton (1987). Specifically in this study, the duration of the low open-mid vowel /ɐ/ was the longest in both positions, followed by the rest of the peripheral vowels, /ɛ/, /o/, /u/, and /i/. In accordance with Fourakis et al. (1999), the high front /i/, had the shortest duration in both positions. The same observation, that vowel duration was correlated with vowel quality in SMG was also made by Dauer (1980), who commented that high vowels appear to be the shortest and "non-high" the longest (p.19). Apart from solely vowel quality, Fourakis et al. (1999) examined the duration changes in slow and fast tempo, and found that when the SMG vowels are produced in slow tempo they are significantly longer to when they are produced in fast tempo. As tempo was not a variable in this study, where only one tempo condition was used, the current findings add to the existing literature by suggesting that although tempo might be an important factor in vowel duration, vowel lengthening was also observed when tempo was kept constant and only the vowel position was altered. Therefore, when the vowels are found in an open syllable, significantly longer vowel durations are observed. Kontosopoulos (1981; 2011), and Themistocleous (2017) have also observed a correlation between vowel duration and stress, by finding unstressed vowels shorter, and often reduced, also complementing the claims of Joseph and Philippaki-Warburton (1987), and Dauer (1980), who suggested that SMG vowels appear longer in a stressed position. Apart from production, the correlation between an increased vowel duration and stress has also been identified as a perceptual cue in Fry (1955).

In addition to vowel duration, this study examined vowel intensity in relation to the position of the vowels in the consonant frame. Although intensity has been found to be higher for stressed vowels (Arvaniti, 2000), this was not confirmed statistically for the vowel productions in this study as vowels both in the medial and final position were produced with the same intensity. The higher intensity in the final position was observed with with the mid-open vowel /ɐ/ and the back rounded vowels /o/, /u/, while the lowest intensity was observed with the having the mid-front /ɛ/ and the high front /i/. The fact that the vowels in neither position were explicitly stressed can lead to the conclusion that vowel position might be enough to affect intensity changes, rather than any additional variables. Botinis (1989) when studying the effects of stress and focus, commented that the duration, fundamental frequency (f_0), and intensity correlate with the above prosodic categories, but they affect them in different ways. He found that focus yielded much higher intensity and f_0 results, which in turn affected vowel duration; however, lexical stress correlated with duration and intensity. In this study, I found that the position of the vowel on the frame correlated with both duration and intensity, while f_0 was not examined.

2.4.1 Conclusions

In this paper I commenced with the history and overview of the SMG vowel system, followed by phenomena that are observed with Greek vowels, such as allophonic variation, vowel deletion, hiatus resolution, and diphthongisation. I then presented the to-date descriptions of the SMG vowel monophthongs based on both phonological and phonetic accounts. Following a review of the existing literature, it became clear that there is no satisfactory description of the SMG vowel system as a degree of controversy governs at least two of the five vowels, namely /ɛ/ and /ɐ/ in terms of their characteristics, status, and positioning on the vowel quadrilateral.

The system so far has been described either through descriptive accounts or through acoustic studies, but the scope of these studies has been limited, either with the studies lacking a substantial number of participants and analysable tokens or lacking up-to-date methodology. SMG in general has also lacked representation in the phonological/ phonetic literature, possibly due to the fact that parallels are often being drawn between SMG and other 5-vowel systems, most frequently Spanish. Fourakis et al. (1999) though, established that the two systems vary in the acoustic characteristics of their vowels, so the comparison of the two systems might be misleading. Also, the IPA notations used for SMG vowels and their implied characteristics might have been inconsistent due to the IPA system itself, which does not account successfully for central vowels, one of which appears in Greek.

In an attempt to address the inconsistent notations and characterisations as well as provide an up-to-date description of the SMG vowel system, I suggested that acoustic measures are used as a more accurate means to position vowels on the vowel quadrilateral and discuss their characteristics. I therefore conducted an acoustic study during which I tested 19 native speakers of SMG by asking them to take part in a production study. It needs to be acknowledged that some participants had also been long term residents in English-speaking countries (and the UK at the time of testing), so they were proficient L2 learners of English. The participants were asked to produce the 5 SMG vowels in /pVpV/ frames incorporated into carrier phrases, following which I obtained and analysed the vowels' spectral measures (those helped position the vowels on the $F_1 \times F_2$ acoustic space), vowel distances and vowel space (helping to reconstruct the entire vowel space area of SMG) as well as temporal measures and intensity (combined, the measures of duration and intensity were used to clarify whether those vary according to the vowels' position, stress, or position). The system description was also essential as a tool to discuss similarities and differences between the small inventory of SMG and the larger one of British English and how speakers of both languages cope with the two varying inventories (to be presented in Chapters 3 and 4).

The analysis of the frequencies of the first (F_1) and second (F_2) formant was used to position the vowels on the $F_1 \times F_2$ acoustic vowel space in order to be able to comment further on their status. All vowels were found to have similarities with some of the previous studies on SMG, while differed with the findings of others. Addressing the three vowels for which there has not been much controversy across studies, (/i/, /o/ and /u/), those were found to be in comparable positions to the previous studies on SMG, such as in Arvaniti (2007), Fourakis et al. (1999), Jongman et al. (1989), Joseph and Philippaki-Warburton (1987), suggesting that the vowels can be characterised in the same way that previous accounts have, as noted in the Discussion section. The findings for the remaining two vowels also complement some of the previous studies. /ɛ/ was found to be in line with the characterisations of Botinis (1981) and Themistocleous (2017), while the acoustic measures for /ɐ/ corresponded to the findings of Botinis (1981) or Joseph and Philippaki-Warburton (1987), but not to those of Arvaniti (2007), Jongman et al. (1989), and Themistocleous (2017). The position of the vowels in the consonantal environment (medial/ final) had some effect on their formant frequencies, which was observed in the statistical findings but also when the frequencies were used to plot the vowels on the $F_1 \times F_2$ space and when the vowel distances and total vowel space area were calculated. Although the vowel distances, with the exception of the /i-o/, /u-i/, and /i-o/ pairs, did not differ significantly with regards to the placement of the vowel in the consonantal environment, the vowels' position in the frame did not have an impact on the overall area acoustic vowel space. The differences in the formant frequencies, did not differ significantly either between vowels in the medial and final position, which was obvious when the vowels were plotted on the $F_1 \times F_2$ space, so the position of the vowels should not play a role in how the vowels are produced in SMG. What could have caused the difference in formant frequencies depending on the position on the frame could be individual variability in productions, even with the same participant, as identified in Ladefoged and Maddieson (1996), who observed variability in a participant's productions of /ə/ from a high front vowel to a central one. However, participant variability was accounted for in this study by normalising the formant measurements prior to analysis. Vowel position on the frame had an impact on the vowels' duration though. As discussed previously, this could be attributed to the fact that frame-final vowels could have been produced with a degree of stress, due tot he syllabic structure of SMG. This resulted in increased durations, complementing the observations made previously by Botinis (1989), Dauer (1980), Joseph and Philippaki-Warburton (1987), Kontosopoulos (1981; 2011), and Themistocleous (2017).

To summarise, the present was a phonetic study on the SMG monophthongs: the vowel system of SMG comprises 5 vowels, the following: /i, ɛ, ɐ, o/ and /u/. /i/ is a high front unrounded vowel, /ɛ/ is mid-open unrounded, /ɐ/ is low and open, while /o/ and /u/ are high, back, and rounded. Distinct vowel categories were observed as part of the system and this observation did not change depending on whether the vowels were produced in the middle or the end of the /pVpV/ frame, contrary to the predictions of Baltazani (2007), Botinis (1981), Disner (1978), Papçun (1976), and Wood (1975), who suggested variability in the vowel positions of a system depending on word stress and acoustic characteristics. Although I focused on the acoustic characteristics of SMG monophthongs here, some topics of SMG phonetics and phonology could be explored in future studies, as so far, they have been under-represented in literature. One of the topics that calls for further exploration is that of hiatus resolution and whether this is done through diphthongisation, for which there is conflicting evidence at the moment.

Chapter 3

Production of Phonemic Contrasts by Greek-English Bilingual Children: Does the Ambient Language Matter?

Abstract

In this study, I am exploring bilingual speech production and whether it can be affected by the linguistic environment the bilinguals are being raised in, especially when two language systems do not share acoustic characteristics. The acoustic characteristics (vowel formants duration, and vowel space) of British English vowels produced by bilingual children were analysed, to address the factors that contribute to production of those vowels. Greek-English bilingual children based in the United Kingdom and in Greece, took part in 3 structured and semi-structured elicitation tasks, where they produced words including the target vowels. A third, control group, of native British English monolingual children was also tested for comparison purposes. The results showed that the bilingual group in Greece produced British English vowels as monolingual controls did, whilst the bilingual group in the UK deviated from monolingual norms. These findings suggest that the quality and quantity of input in each language as well as language

dominance, and usage of each language are important factors in bilingual speech.

3.1 Introduction

Interacting in more than one languages and using them in all modes of communication: speaking, understanding, reading, is an extremely common phenomenon in today's globalised world. Studies on bilingualism have been increasing in popularity during the last 25 years (Kroll & Bialystok, 2003) indicating that there are still unanswered questions on a number of topics, for instance, bilingual speech production, how important are the type and amount of exposure to each of the languages a bilingual uses, as well as whether early representations affect phonological production later in life. In terms of early bilingualism, a range of studies have shown that since an early stage in development, infants are able to identify the sounds of the languages of their environment (Conboy, Rivera-Gaxiola, Klarman, Aksoylu & Kuhl, 2005; Gervain & Mehler, 2011; Werker & Tees, 1984) and also show perceptual sensitivity in correctly pronounced words over mispronounced ones (Bortfeld, Morgan, Golinkoff, & Rathbun, 2005; Mani & Plunkett, 2007; 2010; Swingley, 2005, and others).

Other studies look closer at phonemes that are represented by a single category in one of the languages and two overlapping categories in the other (for instance, Bosch & Sebastián-Gallés, 2003; Ramon-Casas, Swingley, Sebastián-Gallés, & Bosch, 2009). In contrast to studies showing the abilities of bilingual infants to identify not only the sounds of the languages they have been exposed to but also perceive mispronounced phonemes (Ramon-Casas et al., 2009), what happens in older bilinguals is a point of interest. If phonological representations have been well-established since infancy, is this evident in the production of phonemes at a later stage of development in both languages?

Young bilinguals also need to deal with the complexity of the phonemic systems of their two languages, which arises not only because two languages do not share exactly the same inventory (Bosch & Sebastián-Gallés, 2003; Ramon-Casas et al., 2009), but also because apart from phonemic features, the two systems might vary in terms of sizes, categories, and contrasts among categories. Another factor affecting bilingual speech production is the amount of exposure bilingual children get in each of their languages, which is more frequently than not unbalanced, and determines which language will be more dominant. In bilinguals with more exposure to one language, either because of the country they reside in or because of the environment and social interactions bilinguals experience, are phonological representations established in the first few months of life (among others, Iverson, Wagner, & Rosen, 2016; Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992; Kuhl, Tsao, & Liu, 2003) enough to shape the productions of phonemes in each language?

In this paper, I will start by discussing the role of bilingual speech perception in production, by exploring the predictions of the Native Language Magnet (NLM; Kuhl, 1992; 1994; Kuhl, Conboy, Coffey-Corina, Padden, Rivera-Gaxiola, & Nelson, 2007) as well as how the model expands to phonemic representations established at an early stage in life. I will discuss the implications of studies of early phonological representations in production, and how these might affect the speech production of simultaneous bilinguals. In terms of bilingual productions, I will also be discussing the findings of studies focusing on the role of input and language dominance. The role of linguistic environment will also be discussed through the context of language dominance and exposure, as, if other conditions are kept constant, for instance, age, languages spoken, amount of usage, the environment bilinguals grow up in, might suggest increased exposure to one language over the other. I will be exploring those topics by conducting a production study with Greek-English bilingual children residing in Greece and the UK.

3.1.1 Topics in Bilingual Speech Perception and Production

Native Language Magnet

Around their first birthday, infants have been found able to demonstrate acoustic discrimination, by establishing phonemic categories of their native language sounds (for instance, see Conboy et al., 2005; Gervain & Mehler, 2011; Werker & Tees, 1984). In fact, there have been claims that infants up to 6 months of age can demonstrate universal sound recognition, before establishing the phonemic categories of their ambient language (Kuhl et al., 1992). Statistical learning is observed, that is the ability of infants to identify regularities in speech, which aids them perceive specific patterns in the phonemic level, among other areas, (Garcia-Sierra, Rivera-Gaxiola, Percaccio, Conboy, Romo, Klarman, Ortiz, & Kuhl, 2011) an ability for which evidence is available for infants as young as 6 months (Kuhl et al., 1992). As early as 9 months, infants have been found able to recognise sounds of a new language by utilising the phonetic properties of that language, on condition that exposure is through live interlocutors (Kuhl et al., 2003).

Infants' ability to identify the sounds of their native language early in life, can act as a predictor for their linguistic abilities at a later stage, as evidence of behavioural and neurophysiological studies has shown (Conboy et al., 2005; Kuhl, Conboy, Padden, Nelson,& Pruitt, 2005; Molfese, 2000; Tsao, Liu, & Kuhl, 2004). Infants who, for instance, were able to use linguistic input at 6 months to recognise individual sounds, demonstrated an enhanced ability to recognise and produce words, as well as understand longer phrases at 2 years (Tsao et al., 2004). Other studies associating early sound perception to later language skills have found a relationship between poor sound discrimination abilities early in life and later impaired reading performance (Molfese, 2000), overall ability to discriminate sounds (Conboy et al., 2005), and accelerated language abilities after the first year of life (Kuhl et al., 2005). The theory of the Native Language Magnet (NLM; Kuhl, 1992; 1994) and its expanded version (NLM-e; Kuhl et al., 2007) have been developed as explanatory factors to the observation that infants transition from being able to identify all the sounds of the world's languages (Best & McRoberts, 2003; Kuhl, Stevens, Hayashi, Deguchi, Kiritani, & Iverson, 2006) to only identifying those sounds that are present in their ambient language, which is most frequently associated with the infants' native language (Kuhl et al., 2007). Although the identification of non-native sounds seems to become more effortful as infants become older (Best, McRoberts, & Goodell, 2001; Iverson, Kuhl, Akahane-Yamada, Diesch, Tokhura, Kettermann, & Siebert, 2003), such ability is maintained throughout one's lifespan (Flege, 2007).

The Native Language Magnet was initially developed to explain the early perception of infants' phonetic categories and how these could then be structured given the experience infants have with their ambient language (Kuhl, 1992; 1994). The NLM predicts three phases in infants' speech perception development. At the earliest stage, perceptual abilities are predicted to be universal, as infants demonstrate language-general perceptual patterns. During the second phase, given the amount of experience and language-specific input received, infants develop sensitivity to the distributional characteristics of specific sounds, a process termed "warping", an alteration in perception (Kuhl, 1992). As experience with that language increases, those phonological representations activated more frequently are considered the best instances, thus prototypical for that category. This renders them into perceptual magnets for other phonemes in that category, permitting generalisation in the perception of phonemes with similar acoustic characteristics, by increasing their perceptual similarity and facilitating their perception (Kuhl, 1991). This suggests that since perceptual similarity, therefore distance, between members of the same category decreases, the perceptual distance between different categories increases.

In terms of perceptual distance between prototypes and their surrounding sounds, Polka and Bohn (2011) identified the “universal vowel bias”, the fact that vowel discrimination is easier and more accurate when spectral changes occur for vowels that are found in less peripheral positions of the vowel space to more peripheral ones rather than vice versa. They schematically represented, for instance, that it would be easier for listeners to discriminate /ɪ/ changing to /i/ or /ɛ/ changing to /æ/ as both /i/ and /æ/ are found in more peripheral positions, which is in line with the NLM predicting that there is less effortful discrimination of changes from a less prototypical to a more prototypical vowel, considering more prototypical those vowels found in the most extreme positions of the vowel space. Zhao, Masapollo, Polka, Ménard, & Kuhl (2019) however, obtained neurophysiological measures from English-speaking adults in response to a less prototypical English /u/ and a more prototypical French /u/, but found the opposite effect of a native language magnet: rather than the participants demonstrating a universal ability to process native syllables given their extended linguistic experience, the participants only demonstrated sensitivity to specific spectral characteristics, such as a difference in formant frequencies. In the final phase, a “perceptual magnet effect” is identified, during which perceptually similar sounds in a given language are organised around prototypes and can be perceived as such, as opposed to non-native sounds. The magnet effect is what can facilitate the perception of native sounds and hinder that of non-native ones, as prototypical sounds are identified easier.

The expanded version of the perceptual magnet theoretical framework (NLM-e; Kuhl et al., 2007) goes on to add that language-specific sound perception is reinforced by increased exposure to that language, as this is what facilitates perceptual changes at an early phonetic or late auditory level, before the categorisation of phonetic units occurs at a higher level (Iverson, 2003). A second prediction of the model is that although increased language experience reinforces perception of specific sounds at an early age, the same is possible later in life too, as according to the NLM-e there is “native language neural commitment” (NLNC): initial language exposure can create or shape neural networks, therefore physical changes occur that map the properties of the language input. Those changes have an effect on neural networks, which change according to the patterns identified in the speech signal (Kuhl, 2004). During infant development, exposure to a given language creates neural commitment; however, this might not be the case when learning a new language at a later stage, as neural connections to the new language would be immature. This suggests that in order for phonetic learning at a specific language to occur, there needs to be neural commitment (Kuhl, 2004).

The third principle of NLM-e predicts social interactions to be crucial in early phonemic perception, not only in the native, but also in a foreign language. For instance, Maye, Werker, & Gerken (2002) found that exposure to speech for as little as 2 minutes can facilitate statistical learning, an ability documented with infants as young as 9 months old (Kuhl et al., 2003). In terms of social interactions, Kuhl et al. (2003) examined infants exposed to both Mandarin and English and English only, and found that those who heard Mandarin, even though an unfamiliar language to them at the time, were still able to recognise Mandarin syllables and retain this ability even days after testing. Those findings, however, were only replicable when infants were exposed to naturally produced instances of Mandarin from a live interlocutor and not a disembodied source. When those infants were presented the same stimuli from a disembodied source, a television for instance, recognition of the Mandarin sounds did not occur. From those findings, implications can be drawn about the role of naturalistic exposure in phonetic learning.

Iverson et al. (2016), on the other hand, found evidence that phonemic categorisation is possible even when an acoustic signal is manipulated and does not originate from a live source. They did so by presenting English and Japanese adult speakers with /l/ - /r/ stimuli which had their acoustic properties altered. The /l/

- /r/ contrast was chosen as one that exists in English only and is non-contrastive in Japanese, therefore hard for Japanese native speakers to perceive and produce. The findings suggest that experience with a given language can affect the processing of specific sounds even when the stimuli are somewhat manipulated (here in terms of acoustic properties). Although the NLM predicted the ability of infants to perceive and learn phonetic categorisation through live sources, that is, natural speech, the findings of Iverson et al. (2016) demonstrate that this is possible even for sounds in which some acoustic dimension has been changed (such as formant frequencies, temporal dimensions and so on). The fact that the study was conducted with adults rather than infants though might have been a contributing factor to the findings, as adults would have built significant linguistic experience over time to aid with language-specific sound perception, which might still not have been made available to infants.

The fourth principle of the theory, predicts a link between the perceptual representations of sounds learnt through linguistic experience and their production. Kuhl and Meltzoff (1996), for instance, see a developmental link between perception and production: as perceptual mapping occurs with language experience, this guides the development of motor patterns. Infants who have been exposed to a given language, produce vocalisations in that language, which permits to forge a link between their vocalisations and the articulatory movements that caused them. As experience with language grows and more vocalisations are produced, these are stored in memory and aid production.

The final principle of the NLM-e theory suggests that early speech perception can predict future language growth. For instance, Tsao et al. (2004) tested the discrimination abilities of 6-month-old infants and their speech production abilities later in life, 6, 10, and 18 months later. During the discrimination phase at 6 months, infants were tested in the head turning paradigm while listening to the Finnish

/u/ and /y/ sounds, which are perceived by English-speaking adults as instances of /u/ and /i/ respectively, without the latter identifying them as non-native contrasts. Language comprehension and production of the same participants were tested at a later stage, in 6-8-month intervals up to 24 months, through the Communicative Development Inventory (CDI). Infants who demonstrated the ability to discriminate between two acoustically different sounds at 6 months also scored higher at the CDI tests, suggesting a link between auditory perception and later speech production.

To summarise, the perceptual magnet theory refers to auditory processing mechanisms applied to phonetic categories. Perceptual narrowing, is seen in infants of an early age for specific sound categories that reflect prototypes of their ambient language, rather than a universal ability to perceive any sound around them. Although most of the studies examining the model's principles have been conducted with infants and a perceptual magnet effect has been identified as early as 6 months of age, the theory's predictions could also be used to predict language abilities at a later age (Garcia-Sierra et al., 2011) and into adulthood (Polka , Colantonio, & Sundara, 2001; Sundara, Polka, & Genesee, 2006).

The model's principles can be used not only to evaluate the perceptual abilities of both native speakers and learners of a second language, but also make predictions for the production abilities of those groups (for instance, Tsao et al., 2004). Although developed as a theory testing categorical perception of single phones, studies have also found the model's principles applicable to syllables (Kuhl et al., 2003) and intonation features (Rodd & Chen, 2016).

Early Phonological Representations

Early on in infant development and especially over the course of the first 12 months, infants are found to be able to process the sounds of their native language over unfamiliar sounds. Language-specific processing can happen early in life, according to Kuhl et al. (1992), as early as 6 months for one language, and 9 months for a second language (Kuhl et al., 2003), suggesting that phonological representations are created from an early stage. The so-called "perceptual magnet" was used to explain perceptual narrowing for sounds that are around those considered prototypical, perceiving them as more similar to one another than they might actually be.

An interesting concept though that is not clear from this theoretical account is how phonemes are represented for infants, especially for sounds which, although close in the phonetic space, belong to two distinct phonetic categories, as well as how infants make use of those representations in interpreting language. For instance, if categorisation of sounds is dependent on prototypes, the question arises of how sounds that either share phonetic features or have a small perceptual distance are categorised. Also, in cases when changes in phonemic features occur, which might cause variability in the output, I would argue that infants whose language has different categories for individual phonemes would respond in a different manner, as opposed to infants whose language has multiple phonemes for the same category. If phonemes belong to distinct phonetic categories, infants should be able to distinguish each sound, while in the second, both sounds would be treated as equivalent.

The previous would hold true for monolingual infants, but the pattern in bilinguals might be even more complex, given that bilingual infants need to learn the phonetic categories of both their languages, in which there might be some degree of overlap, as no two inventories are exactly the same (Bosch & Sebastián-Gallés, 2003; Ramon-Casas et al., 2009). The sounds of the world's languages are generally structured in the phonetic-acoustic space in such way so that phonemes are spread around the vocalic space and categories are characterised by as much distinctiveness as possible in order to be learnt easier. This holds particularly true for small inventories, where phonemes are represented in the most extreme positions of the space (Liljencrants & Lindblom, 1972); however, for larger inventories, this is harder to maintain, posing challenges for the learners of that language, either monolinguals or bilinguals, especially if the two systems overlap (Ramon-Casas et al., 2009).

In this section, I will briefly address key findings on early phonological representations, before proceeding to discuss issues related to bilingual and early L2 acquisition. Research on early phonological perception tried to establish how bilingual and monolingual infants store phonological and lexical forms as well as how this information is used in phonemic category formation. Swingley (2003), for instance, found that for infants to perceive phonetic categories successfully, great phonetic detail is only necessary at later developmental stages when minimal pairs are learnt. However, perceptual sensitivity to familiar, correctly pronounced words has been found as early as 8 months (Bortfeld et al., 2005), whilst even mispronounced words start being recognised at 11 months as long as consonants are being substituted instead of vowels (Swingley, 2005).

In terms of vowels, studies on monolingual and bilingual infants have focused on phonological and lexical representations in terms of segments whose vowel features have been altered in height, backness, roundness, and so on. Sensitivity has been observed at 12 months (Mani & Plunkett, 2010), but also at 14 (Mani & Plunkett, 2007), and 18 months (Mani et al., 2008). In addition, Dietrich et al. (2007) detected perceptual sensitivity in vowels differing in terms of duration at 18 month-old infants whose native language (Dutch) contrasts between long and short vowels. The fact that older infants did not perceive changes in vowel roundness as cues to identify mispronunciations can be attributed to the fact that vowel roundness is largely associated with vowel backness, so might not be one of the essential cues to categorise a vowel, at least when it comes to English. However, as the same feature was identified in the youngest infants tested (the 12 month-olds) could be due to the fact that those acoustically salient vowel cues are not yet specified, but become such between 12 and 14 months, when the effect is initially reported Mani & Plunkett (2007). When it came to identifying vowel duration, it has been shown that this feature is only recognisable by infants for whom duration is contrastive in their native language. For instance, the same was not reported for English-speaking infants where duration is not an important cue Dietrich et al. (2007).

Bilingual infants, although able to use the same cues as monolinguals, do so somewhat later, during their second year of life (Fennell, Byers−Heinlein, & Werker, 2007). If phonological representations in bilinguals are established by 24 months (Ramon-Casas et al., 2009), then the same pattern and ability to identify acoustically different vowels should be maintained throughout childhood and could be described at a later age too. What has not been described to our knowledge yet, is what happens when infants or older children are presented with more complex cues, for instance, vowel tenseness, which is not only associated with duration, but also aperture, and height (Polka & Werker, 1994). Infants have been successful at identifying changes in one phonetic feature each time Mani & Plunkett (2010), but not multiple ones. The task might be getting more complicated for bilinguals when this combination of features only exists in one of their languages and there are no form similarities between the words of the two languages (for instance, Mani & Plunkett, 2010; Swingley & Aslin, 2000). It could be that bilinguals identify complex cues and use them in their speech production at a later age or that they do not develop those representations at all. Their performance might also be dependent on the amount of familiarity and exposure to each language, as previous studies have made a link between familiarity with specific forms and their successful recognition later.

Successive childhood bilingualism

In today's globalised world, encountering individuals who are exposed to and use two languages, progressively increases. Often, exposure to two languages does not occur simultaneously at birth, but instead, the second language might be introduced and acquired somewhat later in life, after some of the properties of the first language have been established (for instance, Grosjean, 2010). When acquisition of the second language occurs at a stage when L1 properties are in place, it is termed sequential bilingualism or child L2 acquisition (as reviewed in Chondrogianni, 2018). When exposure to the L2 occurs at around 3-4 years and before 7 years, when maturational constraints are in place (Johnson & Newport, 1989), and the rate of acquisition capabilities declines (for instance, Meisel, 2013), the stages of L2 acquisition might resemble that of adult L2 learners, who are exposed to the ;2 at later stages and into adulthood.

Factors that are seen to affect child L2 acquisition are the age of onset (AoO) of the L2, assuming the earlier the better (for instance, Paradis, 2011), the amount and quality of input received (Armon-Lotem & Meir, 2019), including sources such as interactions with family members and peers, educational setting where the L2 might be spoken, and others, like the dominant language of the environment, accessible both in the societal language and through media. Finally, an important role to the development of L2 early in life seems to be held by the parents' socioeconomic status and its potential implications: access to "better" schools, and investment in the children's literacy development.

The effects of age of onset in childhood L2 acquisition have been identified for instance in studies by Meisel (2016), Morrow, Goldstein, Gilhool, and Paradis (2014), McCarthy, Evans, and Mahon (2013). Meisel (2016) studied the acquisition of French gender by German-speaking children who were immersed at a French-speaking setting since an early age. The populations tested included German L1 children being immersed to L2 French between 2;8 and 4 years of age. Although both German and French mark grammatical gender, this is done differently in French where two genders are identified (masculine and feminine) and German, where there are three (masculine, feminine, and neuter). Analysing assignment of grammatical gender in French, Meisel (2016) found that those children who were exposed to French before 3;6 years behaved like native French children in terms of assigning gender to both real and nonsense words, unlike those who were exposed to French after 3;6 years, whose behaviour and errors were more similar to adult L2 learners. The patterns found in Meisel (2016) were not corroborated by Morrow, Goldstein, Gilhool, and Paradis (2014) though, who tested consonant and vowel production accuracy in English-speaking children from a variety of L1 backgrounds in Canada.

In terms of phonology, Chondrogianni (2018) mentions that transfer from L1 to L2 for successive childhood bilinguals is short-lived, drawing evidence from research on Sylheti - English nursery-age children in their productions of plosives. L2 child acquirers started matching L1 production norms after being systematically exposed to English for a year, through schooling and the societal language. McCarthy, Evans, and Mahon (2013) also focused on the effects of age of onset and length of exposure on the formation of consonant and vowel categories by Sylheti - English speakers in Bengali communities in London. Especially for vowels, age of acquisition was an important predictor in how native-like vowel categories were produced. It was found that children who either were exposed to English early in life (before 16 years with a mean age of 6 years) or were born in the UK, so were classified as second generation speakers, produced vowel categories as monolingual English speakers would, both in terms of duration and vowel height and backness. Conversely, speakers who were exposed to English in adulthood, due to immigrating to the UK later in life demonstrated production patterns that resembled more merged categories of English and Sylheti vowels.

Language Exposure and Dominance

As seen previously, phonological representations in bilingual infants have been found to develop early in life (for instance, Fennell, Byers-Heinlein, & Werker, 2007; Mani & Plunkett, 2010; Ramon-Casas et al., 2009; Swingley & Aslin, 2000). Language exposure- the amount of input[1] bilingual infants receive in each of their languages is what helps infants get familiar with specific language patterns and facilitates their learning. Learning the phonology of one's language starts as early as their first months of life and is facilitated through two mechanisms, implicit and explicit learning (Vihman, 2002). Implicit learning, that is learning complex and subtle regularities underlying a language by, for instance, getting accustomed to the distributional characteristics and rhythmic patterns of one or more languages, occurs as early as the gestation period. Fetuses have been found to attune to the patterns of especially their mother's voice, which permits fetuses' exposure to those patterns even before birth (Vihman, 2002).

This early exposure to specific patterns facilitates what is considered familiar later, during the first months of life, either on one language or more. Such familiarity should affect learning, as patterns to which infant have had longer exposure should also be easier to learn. In turn, early familiarisation with the phonological patterns infants have been exposed to implicitly, might have an effect on infants' productions later in life. For instance, the vocalisations of 10-month-olds coming from a variety of linguistic environments (English, French, Cantonese, or Arabic) revealed that exposure to the language of their environment provides the basis shaping the representations of the phonemes in that language, permitting them language-specific vocalisations even as early as the babbling stage (de Boysson-

[1] The terms exposure and input are going to be used interchangeably in this work

Bardies, Hallé, Sagart, & Durand, 1989). This implies that exposure to a language permits the shaping of language-specific representations, which then shapes production.

Explicit learning on the other hand, refers to intentional learning- learning with attention or with a specific purpose (Vihman, 2002). Infants begin establishing phonological representations that are associated with lexical items, so a link between phonological forms, lexical forms, and their meanings is established. In order for perceptual representations to lead to production, infants need not only to learn the phonemes of one or more languages, but also the available contrasts which differentiate the meaning of lexical items, which can be achieved through systematic exposure to those contrasts (Maye et al., 2002). According to Vihman (2002), the phonemes of one language are learnt through exposure to that language from an early age. As exposure increases, explicit links between the phonological forms and their productions are made, which means that production of those language-specific forms is facilitated.

However, the case for bilingual infants should be different, as those need to process and distinguish between the phonemic distributional characteristics in each language they are exposed to. The question then arises of whether representations are organised separately for each of the languages according to the levels of experience bilingual infants have in each, or alternatively whether there are cross-language interactions (Meisel, 2001). I would hypothesise that if there are separate systems developing at different rates depending on experience, infants' responses to the patterns of the language they are more dominant in would result in productions reflecting those language-dominant patterns. However, if both systems operated simultaneously, I would expect processing and production of patterns reflecting the performance of monolinguals in each of the languages.

For instance, Conboy and Mills (2006) tested Spanish-English bilingual infants in their responses to word stimuli presented in the dominant or non-dominant language. Event Related Potentials (ERPs) of 19-22-month-old bilinguals in response to familiar and unfamiliar words were obtained to test whether the amount of exposure in each language would yield different patterns in brain activity. It was expected that if two separate systems had been developed in the infants' minds, after Meisel (2001), different electrophysiological responses would have been elicited for the bilinguals' dominant and non-dominant language in terms of the time course of ERP activation. Alternatively, if cross-language interactions between the systems were observed, there would be evidence for the existence of a general processing mechanism. The findings of Conboy and Mills (2006), latencies in activation depending on the dominance of English or Spanish, supported a combination of exposure and vocabulary size in the performance of bilingual toddlers.

The amount and quality of input received in one language over another is one of the predictors of performance in phonological production, both for infants and adults. Moyer (2011) for instance, argues that the quality of input (or "experiential quality"), that is the type of input bilinguals receive (for instance, language input from native speakers, residence at a setting where a given language is the dominant one or input through instructed settings) has a significant impact on the phonological productions of bilinguals. Adult speakers of two languages were tested in word, sentence and short text recitation, semi-structured interviews on a personal topic, and picture narration and description and their productions were rated by native English speakers (Moyer, 2011). The amount and quality of exposure received, through interactions with native English speakers were strongly correlated to the English productions being rated as closer to monolingual performance.

Not only the amount of exposure, but also language dominance has been found to affect bilingual performance. Although the influence of one language over another has been acknowledged and hypotheses have been drawn that two languages may co-exist in the bilingual mind, not both hold an equivalent status as one of them is argued to be stronger or more dominant (Cutler, Mehler, Norris, & Segui, 1989; 1992; Flege, MacKay, & Piske, 2002), which is often manifested through greater fluency, proficiency, competence, ease of processing, or cultural identification in one of the languages (Amengual & Chamorro, 2015). According to Birdsong (2014), language dominance in bilingualism refers to unbalanced performance in different language skills or language usage for each of the two languages. Unsworth et al. (2018) identify dominance as a complex construct, not only related to which language has a “stronger” status in a bilingual’s mind, but also closely associated with the amount of usage, input, and proficiency.

The effects of language dominance on language production have also been discussed in the literature. For instance, Amengual and Chamorro (2015) tested the effect of language dominance in the perception and production of the Galician mid-vowel contrasts by a group of early onset, Spanish-Galician bilingual adults. Although the Spanish vowel system does not distinguish between open and closed mid vowels, this distinction exists in Galician, therefore, apart from the mid-front /e/ and the mid-back /o/ that are shared between Spanish and Galician, in Galician the open mid-front /ɛ/ and the open mid-back /ɔ/ are also member of the Galician phonemic inventory. The language dominance of the Spanish-Galician bilingual speakers was established through the completion of the Bilingual Language Profile (Birdsong, Gertken, & Amengual, 2012), a battery for bilinguals to self-assess their language use, history, proficiency, and language attitudes in the perception and production of their two languages.

Apart from the questionnaire data, Amengual and Chamorro (2015) used a series of identification tasks, discrimination tasks, and reading aloud tasks to examine whether language dominance played a significant role in the identification, discrimination, and production of the mid-vowel contrasts. The experimental findings suggest that Spanish-dominant bilinguals were not able to discriminate the mid-vowel Galician contrasts, which was not the case with the Galician-dominant bilinguals, who discriminated two distinct categories. The production findings were consistent with the perception ones: Galician-dominant bilinguals were able to produce two distinct categories for the mid vowels /ɛ/ and /e/, unlike the Spanish-dominant bilinguals, who produced a merged vowel. In this study, dominance correlated with earlier exposure or increased daily use for one of the languages, which could be explanatory factors for establishing distinct phonemic representations in the dominant language and use them in production. The fact that daily language usage though still plays a role in one of the languages becoming more dominant even for adults, questions are raised on the implications of daily language usage of bilinguals whose phonetic categories are not yet developed in their languages.

Another language pair where the mid-vowel contrast only exists in one of the languages is Spanish (where the contrast does not exist) and Catalan (where the contrast exists; Amengual, 2011). In a bilingual context where both Spanish and Catalan are spoken on a daily basis, Majorca, adult speakers were tested on their production of Catalan vowels and whether they would maintain the height contrast between /ɛ/ and /e/ as well as /ɔ/ and /o/ in an environment where Spanish was rated as more dominant in language background questionnaires (Amengual, 2011). As part of the testing procedure, the Catalan-Spanish bilinguals were presented with Spanish sentences that needed to be read silently and then translated aloud in Catalan. The study provided evidence that language dominance is a strong predictor in the production of vowels, as Spanish-dominant bilinguals were sensitive to the phonetic distinctions of Spanish as opposed to Catalan-dominant participants who appeared sensitive to the contrasts in their dominant language.

Once again, dominance in one of the languages, determined by a more extended daily language usage to that language was found to be an important predictor in the formation of language-specific categories and the discrimination of fine acoustic contrasts, like formant frequencies to suggest height differences. Since language dominance alone, determined by the amount of daily usage, is found to be affecting the creation of language-specific phonetic categories, would also mean that the environment bilinguals grow up in would affect their ability to establish phonemic categories in the language spoken less. This would hold true provided that bilinguals are exposed to and use the language spoken in their environment on a daily basis. Take, for instance, Simonet (2010), who explored the transfer of alveolar laterals between Spanish and Catalan in a study that focused on whether Spanish-Catalan bilinguals would be able to maintain two distinct acoustic categories for the lateral /l/, which differs in the degree of velarisation in their two languages (velarised in Catalan and not velarised in Spanish). The findings support the hypothesis that phonological transfer exists from the dominant to the non-dominant language.

Language exposure and dominance have been found to affect early phonological representations, of bilinguals both at an early and a later stage in development. The dominant language is one of the factors impacting on phonological productions of bilinguals, both when phonological representations are still developing and later, when they are fully established. Another factor might be the language systems bilinguals are using. To my knowledge, studies of dominance and exposure in bilinguals as well as those assessing the phonological and lexical representations have been done in the context of bilinguals growing up in one country. I would like to explore further how language exposure might impact on speech production of bilinguals growing up in two different countries. This pattern might have an impact on which language is considered more dominant as the amount of input from the language spoken in the country of residence might be different. I am going to explore this further by testing bilinguals in two environments, the UK and Greece.

Apart from language dominance, amount of exposure, and phonemic representations, in this paper so far, I have also demonstrated that bilingual speech production may be influenced by magnet effects relevant to the representations of phonemic categories in the young bilingual brain. Factors such as the language bilinguals may be more dominant in, as well as the amount of input received in each of their languages might also be influencing bilingual productions. Perceptual magnet effects are related to the ability of infants and young acquirers to form phonetic categories based on how prototypical new sounds are considered in elation to already established categories. In the case of bilinguals, this may be applicable to either the categories of a language that is acquired shortly after the first, or to categories bilinguals are exposed to in a less dominant language. An area that has not been addressed by the predictions of the NLM is how or whether a magnet effect occurs in phonemes or contrasts that vary across two languages, either because of the phonemes themselves, or because of the size and organisation of two phonemic systems.

To explore this dimension further, I decided to test the bilingual productions of phonemic contrasts of two languages that differ significantly in terms of their vowel systems, Standard Modern Greek (SMG or Greek for brevity) and British English (BE). I have already given a detailed account of the SMG vowel system from an acoustic perspective in Chapter 2, so I will be summarising those findings here, as well as give an overview of the BE vowels, focusing on those used in this study, before comparing the two systems.

Standard Modern Greek

SMG is a language with a small vocalic system of only 5 vowels, /i/, /ɛ/, /ɐ/, /o/ and /u/. According to the findings of the previous acoustic study (Chapter 2), and in accordance with past acoustic findings (for instance, Jongman, Fourakis, & Sereno 1989; Fourakis, Botinis, & Katsaiti, 1999), /i/ is high, front, and open (see, for instance words like /mˈilo/, *n., singular, neuter; apple*), /ɛ/ (as in /pɛrˈno/, *v., infinitive; (to) go past*) is also front, open, mid, lower than /i/, /ɐ/ is low, central, and open (in words such as /pˈɐli/, *adv.; again*), /o/ is high back, and rounded (in words like /lɛˈpto/, *n., singular, neuter; minute*), and /u/ is also high, back, and rounded (see, for example, words like /luˈluði/, *n., singular, neuter; flower*), higher than /o/. In SMG there is no short - long (or tense - lax) distinction: all vowels have the same length (for instance, see Joseph & Tserdanelis, 2003), unless found in a word-final position, as discussed in the previous chapter, which apart from position might also be an effect of word stress.

British English

The BE system has three times as many vowels and more than one vowel belong to the same category, often being the lax counterpart of a tense vowel, or a rounded equivalent (Knight, 2021). I am only describing here the monophthongs that were used in this study, as described in most English phonology and pronunciation accounts of SSBE (indicatively, Knight, 2012; Ladefoged, 2001; Roach, 2004; 2009). Starting with the high front vowels and moving anti-clockwise, the following vowels are found: /iː/ a tense, high, front, unrounded vowel (like in /biːs/, bees), and its lax counterpart /ɪ/ (as in /tɪk/, tick), which is high, front, close, unrounded.

In the mid-front area there is /ɛ/ (as in /bɛd/, bed), which is lax, open-mid, and unrounded, while lower than that there is /æ/ (as in /hæt/, hat), which is near-open and unrounded. Next, there is /ɜː/ (in words like /gɜːrl/, girl), a tense, open mid-central monophthong, and /ʌ/ (in words such as /cʌt/, cut), which is lax, open-mid, central, and unrounded. Moving towards the back of the quadrilateral, at the lowest positions there is /ɑː/ (like in /hɑːt/), which is tense, open, back, and unrounded, and its lax, rounded equivalent, /ɒ/ (in words such as /cɒt/, cot). At the back mid area, there is /ɔː/ (as in /fɔːt/, fought), which is tense, open-mid, back, and rounded, and higher than that /uː/ and /ʊ/, the first being a tense, close, back, rounded vowel and the second being its lax counterpart (in words such as /nuːn/, noon and /lʊk/, look respectively). The updated IPA chart is provided in Figure **??** for reference (International Phonetic Association (IPA), 2015).

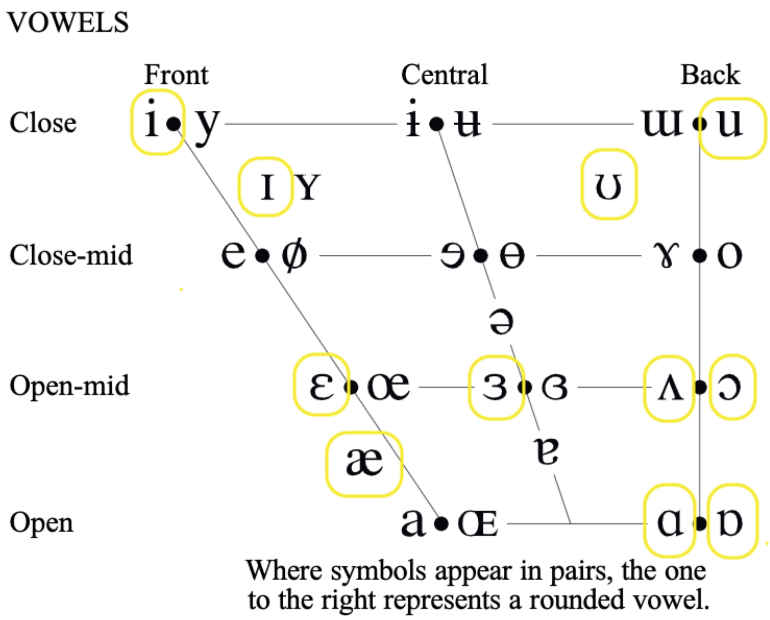


Figure 3.1: Standard Southern British Vowels (International Phonetic Association (IPA), 2015). I have highlighted in yellow the vowels tested in this study.

Comparison of the Two Systems

To summarise the differences between the two systems, I would start from possibly the most striking one, apart from the amount of segments in each inventory, that of the existence of tense - lax vowel contrasts in BE. For instance, contrasts such as /iː/ and /ɪ/ or /uː/ and /ʊ/ are apparent in SSBE, categories that are represented with single categories in SMG, /i/ and /u/. In terms of specific vowel characteristics, the high-front vowel /i/ of SMG is found higher than the SSBE

/ɪ/ and lower than its tense counterpart, while no length distinction is identified. Following on with the SMG open mid-front unrounded /ɛ/, it appears at a similar position to the SMG /ɛ/, between /e/ and /æ/. The open-mid central unrounded /ʌ/ is comparable in the two languages, so are the open-mid back rounded /o/ and the high close back /u/. Finally, height distinctions are observed in SSBE, which are not present in SMG (for instance the height distinction between the open-mid back rounded /ɔː/ and the close-mid back /ɒ/).

3.2 Research Questions and Hypotheses

After reviewing literature related to how bilinguals behave when they need to produce phonemes in each of their languages, as well as how important are factors such as the amount of exposure to one language over the second, dominance and the role phonemic inventories play in bilingual speech production, some questions still remain unanswered. So far, studies have been exploring how phonetic categories are treated by bilinguals when they differ across languages. Much work has been done for instance, on contrasts for which a phoneme might be represented as one phonetic category in one language, but two in another (Dietrich et al., 2007; Ramon-Casas et al., 2007, and others).

Another research focus has been whether exposure is as important and how language dominance might affect bilingual production. Finally, research has focused on the representations of phonetic categories in the early stages of development as well as in the production of those categories later in life. What is also of interest though is how bilinguals produce phonetic categories and features that only exist in one of their languages, but not the other. In addition to that, what can also be addressed is how important is the ambient language in phonological production, as well as factors like quality of input, language usage, and amount of exposure.

Therefore, the first question is whether the linguistic environment bilingual children grow up into can have an effect on the production of vowel contrasts that exist in one of their languages. Also, the question of whether the vowel inventory size in each language the bilinguals are using plays a role in the production of vowel contrasts arises. In response to the research questions, the following hypotheses have been formulated:

First, for bilinguals who live in the UK and are exposed to BE daily, phonological representations of tense and lax vowels that exist in BE, should be well-established, therefore bilinguals should be able to demonstrate those contrasts in production. On the contrary, bilinguals who grow up in Greece and are exposed to SMG more on a daily basis, would have stronger phonological representations of the SMG vowels, where the tense-lax contrast is non-existent, they might find it harder to produce the contrast as successfully. If there is a magnet effect for bilinguals to categories of the language they have more exposure to, then I would expect that BE vowels would be organised closer to prototypical SMG categories, which would also be evident in production: the vowels of bilinguals based in Greece might deviate from monolingual or UK-based bilingual norms in terms of producing the tense-lax contrast.

The fact that BE has a larger vowel inventory size should also affect the productions of bilingual children in the UK, in that longer exposure to and experience with the BE vowel inventory, would permit the usage of those contrasts in production.On the contrary, for bilingual children in Greece for whom the largest amount of exposure is to SMG, a system that has much smaller size and contrasts, might mean that fine acoustic contrasts are not used as successfully in production or are influenced by the properties of the system they are mostly exposed to. To test this, the productions of bilingual children based in two countries, Greece and the UK were tested through elicitation tasks described in the next section.

3.3 Methodology

3.3.1 Participants

Although there are various definitions on what it means to be bilingual and a number of types of bilinguals are identified depending on how their acquired their two languages (simultaneously or sequentially) or depending on the level of confidence using each of their languages (balanced or dominant bilinguals), in this paper, I will consider bilinguals those speakers who use two languages on a regular basis, following Grosjean (1982; 2008) and Grosjean and Li (2012). Most bilingual children were exposed to both English and Greek simultaneously from birth, although there was some variability in terms of the amount of exposure and usage to each language at the time of testing. In the sample of English-Greek bilingual children in the UK, there were also instances of early sequential bilinguals, as per the group description in the following subsection and Tables **??**–**??**. More specifically, in the study took part 61 children, split in three groups: English-Greek bilingual children residing in the UK, another bilingual group residing in Greece, and monolingual controls based in the UK, details of which are presented later in the section. Participant recruitment in the UK was mainly conducted through parental referral after a flyer advertising the study was posted on social media and on mailing lists at the University of Essex. Some parents/ guardians whose children met the eligibility criteria for the study (age, language background) were contacted directly through their preferred means of communication. Those were contacts who had signed up to the University of Essex BabyLab participant database. I reached out to the Greece-based bilingual participants by contacting one of the British English-medium private schools in Athens, who shared details of the study with the students' parents/ guardians.

English-Greek bilingual children: UK

A sample of 21 typically developing bilingual English-Greek children with no reported hearing impairments or learning difficulties was tested in the UK (aged 6.1 years, SD: 2.2, from 4;0-10;0 years, 11 females). One male and one female participant were excluded from the analysis, as they produced few usable responses either by not responding to the tasks set, or by providing few usable tokens. Therefore, the final analysis included 19 participants aged 6.3 years (SD: 2.2), aged between 4;0 and 10;0 years, 10 of whom were females. All participants were growing up in the South East (SE) of England, in or around Colchester, Essex and were being exposed to English either at school only, or both at school and home environment.

Looking at the biographical and language information of the participants in this group, all but 4 were born in the SE of England (8 in Colchester, Essex, 4 in Bishop's Stortford, Essex, and 3 in London) and were residing either in Colchester or in Bishop's Stortford at the time of testing. The remaining 4 participants were born in Athens, Greece and moved to the UK at an early age. 1 participant had lived in Athens for a year, another until age 2, the third until age 3, and another until age 5. In terms of acquiring English, 15 out of 19 considered their children to be "bilinguals from birth" who learnt English as a "native" language. From those children, 7 had one English-speaking parent (for 5 of them the father was a native English speaker, for 1 of them it was the mother, and for 1 more the father was native Mandarin Chinese who used English). It is worth noting that within this "bilingual from birth" group there were also the 4 participants who were born in Athens, Greece. With the exception of one participant whose father was a native English speaker, I will consider the rest as successive bilinguals, following the categorisation of Chondrogianni (2018), as they moved to the UK between 1-5 years (especially the two who moved to the UK at ages 3 and 5 years).

In terms of usage of each language, Greek was reported to be used at home daily for an estimate of 20-60% of the day (35% on average) and was used predominantly with their Greek-speaking mothers and other members of family. English was used for the remainder of the day, at school, with their English-speaking fathers and other family members as well as friends. Further details of the language profiles of the Greek-English bilingual group in the UK can be found in Tables **??**–**??**.

Participant No	Gender	Age	Place & Country of Birth	Years in GR	Years in the UK	Years of EN exposure in GR	Years of EN exposure in the UK	Type of EN education	Mother's level of study & Occupation	Mother's native LA	Father's level of study & Occupation	Father's native LA
10	M	8	Colchester, UK	0	8	0	8	Native	PG, Teacher	Greek	PG, Engineer	English
13	M	4	Colchester, UK	0	4	0	4	Native	PG, Architect	Greek	PhD, Lecturer	Greek
17	F	4	Athens, GR	2	2	2	2	Native	A Levels, Designer	Greek	UG, Teacher	English
18	M	5	Colchester, UK	0	5	0	5	Native	PG, Teacher	Greek	PG, IT Manager	English
34	M	4	Colchester, UK	0	4	0	4	Native	PhD, Lecturer	Greek	PhD, Engineer	Mandarin Chinese
37	F	4	Colchester, UK	0	4	0	4	Native	N/A	Greek	N/A	English
57	F	8	Athens, GR	5	3	5	3	Native	A Levels, Pastry chef	Greek	A Levels, Pastry chef	Greek
89	M	9	Colchester, UK	0	9	0	9	Born in English-speaking environment & schooling	UG, Cardiologist	Greek	UG, Doctor	Greek
90	F	9	Colchester, UK	0	9	0	9	Born in English-speaking environment & schooling	UG, Cardiologist	Greek	UG, Doctor	Greek
91	M	6	London, UK	0	6	0	6	Native	PG, Teacher	Greek	UG, Police Officer	English
92	F	5	Colchester, UK	0	5	0	5	Native	UG, Housewife	Greek	PG, Doctor	Greek
94	M	7.5	Athens, GR	1	6.5	1	6.5	Native	UG, Housewife	Greek	UG, Doctor	Greek
95	F	4	Bishop's Stortford, UK	0	4	0	4	Born in English-speaking environment & schooling	UG, Journalist	Greek	UG, Doctor	Greek

Participant No	Gender	Age	Place & Country of Birth	Years in GR	Years in the UK	Years of EN exposure in GR	Years of EN exposure in the UK	Type of EN education	Mother's level of study & Occupation	Mother's native LA	Father's level of study & Occupation	Father's native LA
96	F	10	Bishop's Stortford, UK	0	10	0	10	Native	PG, Teacher	English	PG, Aircraft Engineer	Greek
97	F	7	Athens, GR	3	4	3	4	Native	UG, Nurse	Greek	UG, Optician	English
98	M	10	Bishop's Stortford, UK	0	10	0	10	Native	PG, Teacher	Greek	PG, Dentist	English
99	M	4	Bishop's Stortford, UK	0	4	0	4	Born in English-speaking environment & schooling	PG, Dentist	Greek	PG, Dentist	Greek
100	F	7.5	London, UK	0	7.5	0	7.5	Born in English-speaking environment & schooling	PG, Dentist	Greek	PG, Dentist	Greek
101	F	5.5	London, UK	0	5.5	0	5.5	Born in English-speaking environment & schooling	PG, Dentist	Greek	PG, Dentist	Greek

Table 3.1: *Biographical and Language background Information of Bilingual children in the UK (Table 1 of 5).*

Participant No	L1	L1 Age of Acquisition	L1 AoE Reading	L1 AoE Writing	L1 AoE Listening	L1 AoE Speaking	L1 Learning Situation	L1 Present use & %	Reading GR Ability (1-5)	Writing GR Ability (1-5)	Listening GR Ability (1-5)	Speaking GR Ability (1-5)
10	Greek	0	0	0	0	0	Home & School	Daily (20%)	1	1	4	4
13	Greek	0	0	0	0	0	Home	Daily (40%)	N/A	N/A	N/A	N/A

Participant No	L1	L1 Age of Acquisition	L1 AoE Reading	L1 AoE Writing	L1 AoE Listening	L1 AoE Speaking	L1 Learning Situation	L1 Present use & %	Reading GR Ability (1-5)	Writing GR Ability (1-5)	Listening GR Ability (1-5)	Speaking GR Ability (1-5)
17	Greek	0	0	0	0	0	Home	Daily (30%)	N/A	N/A	4	4
18	Greek	0	0	0	0	0	Home	Daily (20%)	1	1	4	2
34	Greek	0	0	0	0	0	Home	Daily (20%)	N/A	N/A	5	5
37	Greek	0	0	0	0	0	Home	Daily (60%)	N/A	N/A	5	5
57	Greek	0	0	0	0	0	Home	Daily (50%)	3	5	5	5
89	Greek	0	0	0	0	0	Home	Daily (40%)	5	5	5	5
90	Greek	0	0	0	0	0	Home	Daily (40%)	5	4	5	5
91	Greek	0	0	0	0	0	Home	Daily (30%)	N/A	N/A	5	4
92	Greek	0	0	0	0	0	Home	Daily (40%)	1	1	5	5
94	Greek	0	0	0	0	0	Home	Daily (40%)	4	4	5	5
95	Greek	0	0	0	0	0	Home	Daily (40%)	N/A	N/A	5	5
96	Greek	0	0	0	0	0	Home	Daily (50%)	3	3	5	4
97	Greek	0	0	0	0	0	Home	Daily (40%)	4	4	5	5
98	Greek	0	0	0	0	0	Home	Daily (30%)	5	5	5	5
99	Greek	0	0	0	0	0	Home	Daily (60%)	N/A	N/A	5	5
100	Greek	0	0	0	0	0	Home	Daily (40%)	5	5	5	5
101	Greek	0	0	0	0	0	Home	Daily (40%)	5	5	5	5

Table 3.2: *Biographical and Language background Information of Bilingual children in the UK (Table 2 of 5).*

Participant No	L2	L2 Age of Acquisition	L2 AoE Reading	L2 AoE Writing	L2 AoE Listening	L2 AoE Speaking	L2 Learning Situation	L2 Present use & %	Reading EN Ability (1-5)	Writing EN Ability (1-5)	Listening EN Ability (1-5)	Speaking EN Ability (1-5)
10	English	0	0	0	0	0	Native	Daily (80%)	5	5	4	5
13	English	0	0	0	0	0	Native	Daily (60%)	N/A	N/A	5	5
17	English	0	0	0	0	0	Native	Daily (70%)	N/A	N/A	5	5
18	English	0	0	0	0	0	Native	Daily (80%)	5	3	5	5
34	English	0	0	0	0	0	Native	Daily (80%)	N/A	N/A	5	5
37	English	0	0	0	0	0	Native	Daily (40%)	N/A	N/A	5	5
57	English	5	5	5	5	5	Moved to the UK as a child	Daily (50%)	5	5	5	5
89	English	4	0	0	0	0	School/ Surroundings	Daily (60%)	5	5	5	5
90	English	4	0	0	0	0	School/ Surroundings	Daily (60%)	5	5	5	5
91	English	0	0	0	0	0	Native	Daily (70%)	5	5	5	5
92	English	0	0	0	0	0	Native	Daily (60%)	3	3	5	5
94	English	1	1	1	1	1	Native	Daily (60%)	5	5	5	5
95	English	1	1	1	1	1	School/ Surroundings	Daily (60%)	N/A	N/A	5	5
96	English	0	0	0	0	0	Native	Daily (50%)	5	5	5	5
97	English	0	0	0	0	0	Native	Daily (60%)	5	5	5	5
98	English	0	0	0	0	0	Native	Daily (70%)	5	5	5	5
99	English	0	0	0	0	0	School/ Surroundings	Daily (40%)	N/A	N/A	5	5
100	English	0	0	0	0	0	School/ Surroundings	Daily (60%)	5	5	5	5
101	English	0	0	0	0	0	School/ Surroundings	Daily (60%)	5	5	5	5

Table 3.3: *Biographical and Language background Information of Bilingual children in the UK (Table 3 of 5).*

Participant No	LA used in daily life	LA used when spoke first	LA used by mother	LA used by father	LA Acquisition circumstances	LA Spoken with Family	LA Spoken with Friends
10	GR-EN	GR-EN	Greek	English	Bilingual from birth	GR-EN	English
13	GR-EN	GR-EN	Greek	Greek	Bilingual from birth	Greek	GR-EN
17	English	GR-EN	GR-EN	GR-EN	Bilingual from birth	GR-EN	GR-EN
18	GR-EN	GR-EN	GR-EN	English	Bilingual from birth	GR-EN	English
34	GR-EN	GR-EN	GR-EN	English	Bilingual from birth	GR-EN	English
37	GR-EN	GR-EN	Greek	English	Bilingual from birth	GR-EN	GR-EN
57	GR-EN	Greek	Greek	Greek	Native Greek L2 Acquirer	Greek	English
89	GR-EN	Greek	Greek	Greek	Born in English-speaking country	Greek	GR-EN
90	GR-EN	Greek	Greek	Greek	Born in English-speaking country	Greek	GR-EN
91	English	Greek	Greek	English	Bilingual from birth	GR-EN	GR-EN
92	GR-EN	GR-EN	Greek	Greek	Born in English-speaking country	Greek	English
94	GR-EN	GR-EN	Greek	Greek	Moved to English-speaking country as an infant	Greek	English
95	GR-EN	Greek	Greek	GR-EN	Born in English-speaking country	GR-EN	GR-EN
96	GR-EN	GR-EN	English	GR-EN	Bilingual from birth	GR-EN	GR-EN
97	GR-EN	Greek	Greek	English	Bilingual from birth	GR-EN	GR-EN
98	GR-EN	Greek	Greek	English	Bilingual from birth	GR-EN	GR-EN
99	GR-EN	Greek	Greek	Greek	Born in English-speaking country	Greek	GR-EN
100	GR-EN	Greek	Greek	Greek	Born in English-speaking country	Greek	GR-EN
101	GR-EN	Greek	Greek	Greek	Born in English-speaking country	Greek	GR-EN

Table 3.4: *Biographical and Language background Information of Bilingual children in the UK (Table 4 of 5).*

Participant No	Setting of using L1	Setting of using L2	LA Preference Speaking	LA Preference Listening	LA Preference Reading	LA Preference Writing
10	home	home/ school	English	English	English	English
13	home	surroundings/ school	English	GR-EN	N/A	N/A
17	home	home/ surroundings/ school	English	GR-EN	N/A	N/A
18	home	home/ surroundings/ school	English	English	English	English
34	home	home/ school	English	English	N/A	N/A
37	home	surroundings/ school	Greek	English	N/A	N/A
57	home	surroundings/ school	English	Greek	English	English
89	home	surroundings/ school	English	English	GR-EN	GR-EN
90	home	surroundings/ school	English	English	GR-EN	GR-EN
91	home	surroundings/ school	English	English	English	English
92	home	home/ surroundings/ school	English	English	English	English
94	home	surroundings/ school	English	GR-EN	GR-EN	English
95	home	surroundings/ school	English	GR-EN	N/A	N/A
96	home	surroundings/ school	GR-EN	GR-EN	English	English
97	home	home/ surroundings/ school	GR-EN	GR-EN	English	English
98	home	home/ surroundings/ school	English	GR-EN	GR-EN	English
99	home	surroundings/ school	Greek	Greek	GR-EN	English
100	home	surroundings/ school	Greek	Greek	GR-EN	English
101	home	surroundings/ school	Greek	Greek	GR-EN	English

Table 3.5: *Biographical and Language background Information of Bilingual children in the UK (Table 5 of 5).*

English-Greek Bilingual Children: Greece

The second participant group was that of typically developing English-Greek bilingual children based in Athens, Greece. 20 typically developing participants (aged 7.1 years, SD: 1.8, from 4;0-10;0 years, 13 females) took part in the data collection process. Two of the participants were rejected from the final sample, due to insufficient usable responses, therefore, the responses of 18 children (aged 7.4 years, SD: 1.6, aged 4;0-10;0, 12 females) were analysed in the end. All children were born in Athens, Greece, apart from one who was born in London, UK and remained there until 1;6 years, before coming to Greece. Three more participants were recorded to have resided in the UK, one for 4 years and two more for 2 years during their lifespan, but no further details were offered as to what age they were whilst in the UK.

All participants were considered bilinguals from birth as one of their parents was a native English speaker (for 10 out of the 18 participants this was the father and for the remaining 8 the mother) and were all attending a British English medium Primary school at the time of testing. Parental estimations about the percentage Greek and English language use per day revealed that Greek was used between 30 and 70% of the day (on average 45.5%) and was used both in the interactions with family and friends. For the remainder of the day, participants were estimated to use English, during the school day as well as with family and friends. Further details of the language profiles of the Bilingual English-Greek group in Greece can be seen in Tables **??**–**??** below.

Participant No	Gender	Age	Place & Country of Birth	Years in GR	Years in the UK	Years of EN exposure in GR	Years of EN exposure in the UK	Type of EN education	Mother's level of study & Occupation	Mother's native LA	Father's level of study & Occupation	Father's native LA
58	F	6	Athens, GR	6	0	6	0	English speaking school & father	Banker, UG	Greek	Solicitor, UG	English
59	F	6.5	Athens, GR	6.5	0	6.5	0	English speaking school & father	English Teacher, UG	Greek	Businessman, UG	English
60	F	10	Athens, GR	4	6	4	6	English speaking school & father	Nursery teacher, UG	Greek	Dentist, PG	English
62	F	6	Athens, GR	6	0	6	0	English speaking school & mother	Designer, UG	English	Architect, UG	Greek
63	M	9.5	Athens, GR	9.5	0	9.5	0	English speaking school & father	Teacher, PG	Greek	Accountant, UG	English
64	M	5.5	Athens, GR	5.5	0	5.5	0	English speaking school & mother	Linguist, PhD	English	Pharmacist, PG	Greek
65	M	5.5	Athens, GR	5.5	0	5.5	0	English speaking school & mother	Linguist, PhD	English	Pharmacist, PG	Greek
66	F	9	Athens, GR	9	0	9	0	English speaking school & father	Orthodontist, PG	Greek	Solicitor, UG	English
67	F	5.5	Athens, GR	5.5	0	5.5	0	English speaking school & father	Nutritionist, UG	Greek	Doctor, PG	English
68	M	8	Athens, GR	6	2	6	2	English speaking school & mother	Teacher, PG	English	Businessman, PG	Greek
70	F	5.5	Athens, GR	5.5	0	5.5	0	English speaking school & father	Psychologist, UG	Greek	Teacher, UG	English
71	M	9.5	London, UK	8	1.5	8	1.5	English speaking school & father	Nursery Teacher, UG	Greek	Lecturer, PhD	English
72	F	7	Athens, GR	3	4	3	4	English speaking school & mother	Teacher, PG	English	Company Director, PG	Greek
73	F	8.5	Athens, GR	8.5	0	8.5	0	English speaking school & father	Business Owner, UG	Greek	Dentist, PG	English
74	F	7.5	Athens, GR	5.5	2	5.5	2	English speaking school & mother	Sole Trader, UG	English	Business Owner, UG	Greek
75	M	7	Athens, GR	7	0	7	0	English speaking school & mother	N/A	English	N/A	Greek
76	F	9	Athens, GR	9	0	9	0	English speaking school & mother	Teacher, PG	English	Public Servant, PG	Greek
77	F	9	Athens, GR	9	0	9	0	English speaking school & father	Doctor, UG	Greek	Doctor, PG	English

Table 3.6: *Biographical and Language background Information of Bilingual children in Greece (Table 1 of 5).*

Participant No	L1	L1 Age of Acquisition	L1 AoE Reading	L1 AoE Writing	L1 AoE Listening	L1 AoE Speaking	L1 Learning Situation	L1 Present use & %	Reading GR Ability (1-5)	Writing GR Ability (1-5)	Listening GR Ability (1-5)	Speaking GR Ability (1-5)
58	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (30%)	1	1	5	5
59	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (60%)	4	3	5	5
60	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (50%)	4	5	5	5
62	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (70%)	N/A	N/A	5	5
63	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (40%)	4	4	4	4
64	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (40%)	N/A	N/A	5	5
65	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (40%)	N/A	N/A	5	5
66	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (60%)	5	5	5	5
67	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (50%)	4	5	5	4
68	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (30%)	5	5	5	5
70	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (40%)	N/A	N/A	4	4
71	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (50%)	5	5	5	5
72	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (40%)	4	4	4	4
73	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (50%)	5	5	5	5
74	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (40%)	4	3	5	4
75	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (50%)	5	4	5	5
76	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (30%)	3	3	3	3
77	Greek	0	0	0	0	0	Home/ School/ Surroundings	Daily (50%)	5	5	5	5

Table 3.7: *Biographical and Language background Information of Bilingual children in Greece (Table 2 of 5).*

Participant No	L2	L2 Age of Acquisition	L2 AoE Reading	L2 AoE Writing	L2 AoE Listening	L2 AoE Speaking	L2 Learning Situation	L2 Present use & %	Reading EN Ability (1-5)	Writing EN Ability (1-5)	Listening EN Ability (1-5)	Speaking EN Ability (1-5)
58	English	0	0	0	0	0	English-speaking school & bilingual from father	Daily (70%)	4	3	5	5
59	English	0	0	0	0	0	English-speaking school & bilingual from father	Daily (40%)	4	4	4	4
60	English	0	0	0	0	0	English-speaking school & bilingual from father	Daily (50%)	5	5	5	5
62	English	0	0	0	0	0	English-speaking school & bilingual from mother	Daily (30%)	N/A	N/A	5	5
63	English	0	0	0	0	0	English-speaking school & bilingual from father	Daily (60%)	5	5	5	5
64	English	0	0	0	0	0	English-speaking school & bilingual from mother	Daily (60%)	N/A	N/A	5	5
65	English	0	0	0	0	0	English-speaking school & bilingual from mother	Daily (60%)	N/A	N/A	5	5
66	English	0	0	0	0	0	English-speaking school & bilingual from father	Daily (40%)	5	5	5	5
67	English	0	0	0	0	0	English-speaking school & bilingual from father	Daily (50%)	5	5	5	5
68	English	0	0	0	0	0	English-speaking school & bilingual from mother	Daily (70%)	5	5	5	5
70	English	0	0	0	0	0	English-speaking school & bilingual from father	Daily (60%)	N/A	N/A	5	5
71	English	0	0	0	0	0	English-speaking school & bilingual from father	Daily (50%)	5	5	5	5
72	English	0	0	0	0	0	English-speaking school & bilingual from mother	Daily (60%)	5	5	5	5
73	English	0	0	0	0	0	English-speaking school & bilingual from father	Daily (50%)	5	5	5	5
74	English	0	0	0	0	0	English-speaking school & bilingual from mother	Daily (60%)	5	5	5	5
75	English	0	0	0	0	0	English-speaking school & bilingual from mother	Daily (50%)	5	5	5	5
76	English	0	0	0	0	0	English-speaking school & bilingual from mother	Daily (70%)	5	5	5	5
77	English	0	0	0	0	0	English-speaking school & bilingual from mother	Daily (50%)	5	5	5	

Table 3.8: *Biographical and Language background Information of Bilingual children in Greece (Table 3 of 5).*

Participant No	LA used in daily life	LA used when spoke first	LA used by mother	LA used by father	LA Acquisition circumstances	LA Spoken with Family	LA Spoken with Friends
58	GR-EN	GR-EN	Greek	English	Bilingual from birth	GR-EN	GR-EN
59	GR-EN	GR-EN	Greek	English	Bilingual from birth	GR-EN	GR-EN
60	GR-EN	GR-EN	Greek	English	Bilingual from birth	GR-EN	GR-EN
62	GR-EN	GR-EN	English	Greek	Bilingual from birth	GR-EN	GR-EN
63	GR-EN	GR-EN	Greek	English	Bilingual from birth	GR-EN	GR-EN
64	GR-EN	GR-EN	English	Greek	Bilingual from birth	GR-EN	GR-EN
65	GR-EN	GR-EN	English	Greek	Bilingual from birth	GR-EN	GR-EN
66	GR-EN	GR-EN	Greek	English	Bilingual from birth	GR-EN	GR-EN
67	GR-EN	GR-EN	Greek	English	Bilingual from birth	GR-EN	GR-EN
68	GR-EN	GR-EN	English	Greek	Bilingual from birth	GR-EN	GR-EN
70	GR-EN	GR-EN	Greek	English	Bilingual from birth	GR-EN	GR-EN
71	GR-EN	GR-EN	English	Greek	Bilingual from birth	GR-EN	GR-EN
72	GR-EN	GR-EN	English	Greek	Bilingual from birth	GR-EN	GR-EN
73	GR-EN	GR-EN	Greek	English	Bilingual from birth	GR-EN	GR-EN
74	GR-EN	GR-EN	English	Greek	Bilingual from birth	GR-EN	GR-EN
75	GR-EN	GR-EN	English	Greek	Bilingual from birth	GR-EN	GR-EN
76	GR-EN	GR-EN	English	Greek	Bilingual from birth	GR-EN	GR-EN
77	GR-EN	GR-EN	Greek	English	Bilingual from birth	GR-EN	GR-EN

Table 3.9: *Biographical and Language background Information of Bilingual children in Greece (Table 4 of 5).*

Participant No	Setting of using L1	Setting of using L2	LA Preference Speaking	LA Preference Listening	LA Preference Reading	LA Preference Writing
58	home/ school/ surroundings	home/ school	GR-EN	GR-EN	GR-EN	GR-EN
59	home/ school/ surroundings	home/ school	English	English	English	English
60	home/ school/ surroundings	home/ school	GR-EN	GR-EN	GR-EN	GR-EN
62	home/ school/ surroundings	home/ school	English	English	English	English
63	home/ school/ surroundings	home/ school	English	English	Greek	Greek
64	home/ school/ surroundings	home/ school	Greek	Greek	English	English
65	home/ school/ surroundings	home/ school	Greek	Greek	English	English
66	home/ school/ surroundings	home/ school	English	English	English	English
67	home/ school/ surroundings	home/ school	GR-EN	GR-EN	GR-EN	GR-EN
68	home/ school/ surroundings	home/ school	English	English	English	English
70	home/ school/ surroundings	home/ school	English	English	English	English
71	home/ school/ surroundings	home/ school	English	Greek	GR-EN	English
72	home/ school/ surroundings	home/ school	English	English	English	English
73	home/ school/ surroundings	home/ school	GR-EN	GR-EN	GR-EN	GR-EN
74	home/ school/ surroundings	home/ school	English	GR-EN	GR-EN	English
75	home/ school/ surroundings	home/ school	English	GR-EN	English	GR-EN
76	home/ school/ surroundings	home/ school	English	English	English	English
77	home/ school/ surroundings	home/ school	GR-EN	GR-EN	GR-EN	GR-EN

Table 3.10: *Biographical and Language background Information of Bilingual children in Greece (Table 5 of 5).*

British English Monolingual Children

The final group recruited was a sample of 20 typically developing children (aged 6.9 years, SD: 2.4, from 4;0 to 10;0 years; 11 female). However, because of producing insufficient usable tokens, 4 of the participants were excluded from the analysis. Therefore, the responses of 16 participants (aged 6.8 years, SD: 2.4, from 4;0 to 10;0 years; matched for gender) were analysed. All participants were monolingual native British English speakers growing up in monolingual British English families based in the South East of England (in or around Colchester, Essex), similarly to the UK-based bilingual group. Therefore, their everyday language usage and exposure was solely in English and they had not received any other language input, so they can be considered a good sample of monolingual controls. Details of their profiles can be found in Tables **??**–**??** below.

Participant No	Gender	Age	Place & Country of Birth	Years in the UK	Years of EN exposure in the UK	Type of EN education	Mother's level of study & Occupation	Mother's native language	Father's level of study & Occupation	Father's native language
1	F	4	Colchester, UK	4	4	Native	Receptionist, UG	English	Web Developer, A Levels	English
2	M	9	Colchester, UK	9	9	Native	Administrator, UG	English	Plumber, A Levels	English
3	F	7	Colchester, UK	7	7	Native	Administrator, UG	English	Plumber, A Levels	English
5	F	9	Colchester, UK	9	9	Native	Student, UG	English	N/A, GCSE	English
7	F	10	Ipswich, UK	10	10	Native	Midwife, UG	English	Deputy Headteacher, UG	English
8	M	9	Colchester, UK	9	9	Native	Finance Officer, A Levels	English	Administrator, A Levels	English
9	F	10	Colchester, UK	10	10	Native	HR Officer, UG	English	Deputy Headteacher, UG	English
12	M	6	Colchester, UK	6	6	Native	Teacher, PG	English	Researcher, PhD	English
14	F	4	Colchester, UK	4	4	Native	Careers Adviser, PG	English	Driver, A Levels	English
16	F	10	Colchester, UK	10	10	Native	Careers Adviser, PG	English	Marketing Manager, UG	English
39	F	5	Colchester, UK	5	5	Native	Housewife, A Levels	English	N/A	English
41	M	4	Colchester, UK	4	4	Native	Housewife, A Levels	English	Shop Assistant, A Levels	English
42	M	4	Colchester, UK	4	4	Native	Social Worker, PG	English	Practice Manager, UG	English
43	M	5	Colchester, UK	5	5	Native	Social Worker, PG	English	Practice Manager, UG	English
44	F	7	Colchester, UK	7	7	Native	Social Worker, PG	English	Practice Manager, UG	English
45	F	10	Colchester, UK	10	10	Native	Librarian, PG	English	Journalist, PG	English

Table 3.11: *Biographical and Language background Information of Monolingual children in the UK (Table 1 of 3).*

Participant No	L1	L1 Age of Acquisition	L1 AoE Reading	L1 AoE Writing	L1 AoE Listening	L1 AoE Speaking	L1 Learning Situation	L1 Present use & %	Reading EN Ability (1-5)	Writing EN Ability (1-5)	Listening EN Ability (1-5)	Speaking EN Ability (1-5)
1	English	0	0	0	0	0	Native	Daily (100%)	4	3	5	5
2	English	0	0	0	0	0	Native	Daily (100%)	5	4	5	5
3	English	0	0	0	0	0	Native	Daily (100%)	4	4	5	5
5	English	0	0	0	0	0	Native	Daily (100%)	5	5	5	5
7	English	0	0	0	0	0	Native	Daily (100%)	5	5	5	5
8	English	0	0	0	0	0	Native	Daily (100%)	4	3	4	5
9	English	0	0	0	0	0	Native	Daily (100%)	4	3	5	5
12	English	0	0	0	0	0	Native	Daily (100%)	5	5	5	5
14	English	0	0	0	0	0	Native	Daily (100%)	N/A	N/A	5	5
16	English	0	0	0	0	0	Native	Daily (100%)	5	5	5	5
39	English	0	0	0	0	0	Native	Daily (100%)	5	5	5	5
41	English	0	0	0	0	0	Native	Daily (100%)	5	5	5	5
42	English	0	0	0	0	0	Native	Daily (100%)	N/A	N/A	5	5
43	English	0	0	0	0	0	Native	Daily (100%)	5	5	5	5
44	English	0	0	0	0	0	Native	Daily (100%)	5	5	5	5
45	English	0	0	0	0	0	Native	Daily (100%)	5	4	5	5

Table 3.12: *Biographical and Language background Information of Monolingual children in the UK (Table 2 of 3).*

Participant No	LA used in daily life	LA used when spoke first	LA used by mother	LA used by father	LA Acquisition circumstances	LA Spoken with Family	LA Spoken with Friends	Setting of using L1	LA Preference Speaking	LA Preference Listening	LA Preference Reading	LA Preference Writing
1	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
2	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
3	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
5	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
7	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
8	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
9	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
12	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
14	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
16	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
39	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
41	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
42	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
43	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
44	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English
45	English	English	English	English	Native	English	English	home/ surroundings/ school	English	English	English	English

Table 3.13: *Biographical and Language background Information of Monolingual children in the UK (Table 3 of 3).*

3.3.2 Tasks

The participants' BE vowel production was tested through three structured and semi-structured picture naming elicitation tasks, which were designed specifically for this study. The rationale behind using both structured and semi-structured elicitation tasks was trifold: first of all, it was important to design engaging tasks that would be suitable for all the participants within the age range tested (4;0-10;0 years). Secondly, there was an attempt to select and create picture items that the younger participants would be familiar with, both in the UK and in Greece. Finally, the semi-structured elicitation tasks would provide a relaxed enough and natural environment for the participants to produce their responses at: one where they would not feel as if they are taking part in a formal "experiment", but more as if they are taking part in games (Eisenbeiß, 2009). In order to obtain comparable results and for the purposes of consistency, the same set of items was used for all tasks: the first task included a short version comprising 2/3 of the items (30 items in total), while the rest two tasks included a full set of items (45 items, as described in section **??**).

Task 1: Story Book

The first task presented to the participants was a story book, entitled "The animals are going on a picnic", the theme of which was selected as it is a rather recurring one in children's literature; children as early as 4 years old are both familiar with the concept and the actions occurring while preparing for and during a picnic, as well as with the names of different animals. The story book was laid out over 32 pages and comprised several simple sentences. From these sentences, 30 words were selected and replaced by pictures: the test items to which the children were required to respond to, by naming them. The items were presented in a random order so that not the same vowel or consonant frame appeared consecutively. The only restriction of the randomisation process was that overall there needed to be a meaningful and coherent story, so apart from ensuring that not the same vowel or consonant frame in consecutive words, no specific order was maintained. A sample page from the story book can be viewed in Figure **??**.

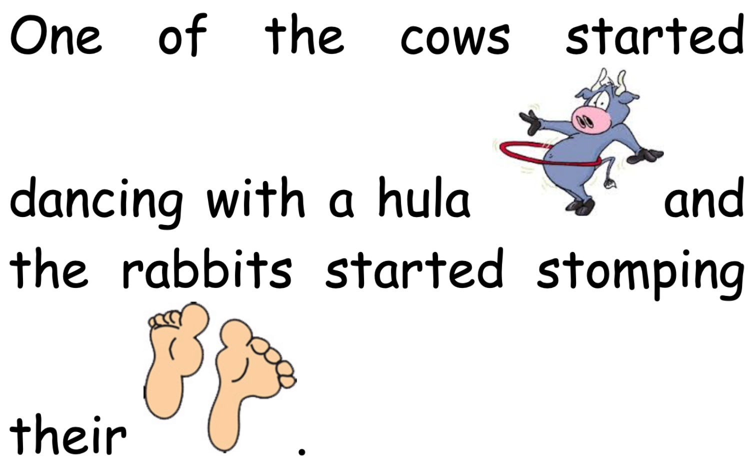


Figure 3.2: Story book sample page with two words elicited

This task, as previously mentioned, was the first to be presented, because as the picture items were presented in a story/ sentence context, this would help improve the participants' production accuracy compared to the items being presented in isolation. The participants were introduced to the task by being told that the story was going to be read to them; at the same time, they were introduced to the title and were shown the cover page. As part of the instructions, the participants were also told that some words in the story were replaced by pictures to which they would need to respond by naming them, while their voice was being recorded, at which point the children were shown an example page of the story for the purposes of familiarisation. In addition to those instructions, the older child subgroup (aged 7-10 years old; 8 children in the UK-based group and 10 children in the Greece-based group) was given additional information: they were told that because the story book is designed for younger children, the experimenter would need some feedback at the end of the task on whether the story would be suitable for its target audience. This additional instruction was provided in order to encourage the older children to remain engaged throughout the task.

Throughout the experimental procedure participants were addressed to in English by the experimenter who was also the one who conducted the tasks.

Task 2: Matching Task

The second elicitation task administered was a confederate description task, related again with naming various picture items. A series of picture cards (45 items) was presented to the participant groups by the means of a timed PowerPoint presentation. Each item was presented individually in the middle of the slide on a white background and was displayed on the screen for 4 seconds. The duration for the presentation of each slide was determined after piloting the task to both young and older children and was deemed to have the appropriate duration both for the participants to be able to name the pictures clearly and not to get tired and disengaged. After its presentation, each stimulus disappeared and the following item was automatically presented.

The presentation of stimuli was randomised in order to avoid displaying the story book subset picture items in the same order as previously appear, so as to avoid training effects (Eisenbeiß, 2009). However, a certain order was still maintained, which would be useful in the third task. During this task, the participants were asked to name each picture as it appeared on the screen, while their responses were also audio recorded. At the same time as the participants were naming the picture stimuli, the experimenter was sorting the same pictures in the form of picture cards in a folder. This way, the task turned into a “race” between the participant and the experimenter: the children were encouraged to try their best in naming all the pictures before the experimenter was able to find them in her folder, so as to make the task fun and engaging throughout its duration.

Task 3: New Story

Following two tasks for which the test items were produced in isolation, the third task required the participants to produce the the same test items as in the second task in context. This format was chosen to review any effects in production depending on the task type and also provided an alternative to the previous tasks to encourage participant engagement. Therefore, after the 45 picture cards were sorted in the experimenter's folder as part of the Matching task, the children were then asked to use those pictures in a new story. They were encouraged to use the stimuli in the order they were presented in the folder in order to make sentences of their own that would make up a new story. The order for the presentation of stimuli was maintained from the previous task and the children were asked to use their imagination and create their own special story on any topic. In the case of very young participants who were not familiar with making up meaningful sentences, the experimenter was prompting them with questions related to the pictures presented without revealing the word though. In all other cases, the participants were able to create their stories independently, without the experimenter's help.

3.3.3 Materials and Stimuli

Test items

To better understand whether the bilingual children from two different linguistic environments would produce BE vowels as monolingual children growing up in the UK would do, 11 British English monophthongs were selected, which helped develop the test items for the study. Those vowels the following: /iː/, /uː/, /ɜː/, /ɑː/, /ɔː/, /ɪ/, /ʊ/, /ɛ/, /æ/, /ɒ/, and /ʌ/. In order to create meaningful words for the vowels to be produced in, the items were placed in recurrent consonant frames (for instance: /kVt/, /hVt/, /bVd/ and so on. The detailed account of consonant frames used, vowels, and the words they were incorporated into can be viewed in tables **??** (Task 1) and **??** (Tasks 2-3). The consonant frames were used so as to ensure a controlled environment for the vowels to be presented and produced in. Another criterion that was maintained for all the items was that they were presented in stressed positions, which was particularly important for children to improve their production accuracy, by making the vowels of interest more acoustically salient (Core, 2012).

The consonant frames selected had to meet specific criteria: for instance, only voiced and voiceless stops were chosen (/p/, /t/, /k/, /b/, /d/, /g/), voiceless coronal fricatives (/s/ and /ʃ/), the voiceless labiodental fricative (/f/), as well as the voiceless fricative /h/ on either side of the frame or being neutral and not affecting the production of the following vowels (Hillenbrand, Clark, & Nearey, 2001). The only exception was one frame (/hVn/), but since the vowel was presented before the nasal, this would not affect the production of the vowel, by creating nasalisation or assimilation effects (Cohn, 1993). All the items initially generated and then selected for the task were real words that could be replaced by pictures and that according to the Department for Education (DfES) (2006) would be recognisable by the youngest participants; the 4-year-old children.

Each vowel was used in two words (22 items in total) in the first task and in three words (33 items in total) in the second and third tasks, so the number of occurrences of each vowel per task was controlled for. 4 diphthongs were also included (/oʊ/, /aɪ/, /aʊ/, /eɪ/) as fillers, so the total number of items for the first task was 30 and 45 for the rest two tasks. A detailed account of the consonant frames, stimuli, and vowels used can be found in Tables **??** and **??**.

Table 3.14: *Consonant Frame Frequencies and Words per Vowel Token in Task 1*

Target Vowel	Frequency	Consonant frame	Words
æ	2	k_t	cat
		h_t	hat
ɐ	2	k_t	cut
		h_n	honey
ɑː	2	k_t	cart
		h_t	heart
ɒ	2	h_t	hot
		ʃ_p	shop
ɜː	2	b_d	bird
		ʃ_t	shirt
iː	2	ʃ_p	sheep
		f_t	feet
ɪ	2	ʃ_p	ship
		h_p	hippo
ɔː	2	h_n	horn
		h_s	horse
uː	2	h_p	hoop
		b_t	boot
ʊ	2	f_t	foot
		h_d	hood
ɛ	2	k_t	kettle
		b_d	bed

Table 3.15: *Consonant Frame Frequencies and Words per Vowel Token in Tasks 2 and 3*

Target Vowel	Frequency	Consonant frame	Words
æ	3	k_t	cat
		h_t	hat
		b_g	bag
ɐ	3	k_t	cut
		h_n	honey
		m_n	monkey
		s_n	sun
ɑː	2	k_t	cart
		h_t	heart
ɒ	3	h_t	hot
		ʃ_p	shop
		d_g	dog
ɜː	3	b_d	bird
		ʃ_t	shirt
		g_l	girl
iː	3	ʃ_p	sheep
		f_t	feet
		p_s	peas
ɪ	3	ʃ_p	ship
		h_p	hippo
		p_g	pig
ɔː	3	h_n	horn
		h_s	horse
		s_d	sword
uː	3	h_p	hoop
		b_t	boot
		m_n	moon
ʊ	3	f_t	foot
		h_d	hood
		b_k	book
ɛ	3	k_t	kettle
		b_d	bed
		p_n	pencil

Experimental Procedure

After the parents'/ guardians' informed consent, during the testing procedure only the experimenter and the child participant were present in order to minimise distractions, while the accompanying adults were waiting at a neighbouring room. In the case of the children taking part in the study in Greece, all recordings were conducted during school hours, so the parents, although not present at school, had already given their consent for the experimenter to meet the children alone. The study at Campion school was conducted with the consent and cooperation of the participants' teachers, who were based at the neighbouring classrooms at the time of testing. Therefore, the recording quality and testing conditions were controlled as much as possible during the testing procedure. Another condition that was maintained in both settings to ensure that there would be no distractions and participants would be completing the tasks assigned was that in all experimental sessions the children were assigned non-swivel chairs. Finally, the participants were addressed in English at all times during the experimental procedure to ensure consistency.

Equipment

A Sennheiser MD42 omnidirectional microphone was mounted on a table base and placed facing sideways and at approximately a 10 cm distance from the participant's mouth. The microphone was connected to a Behringer Xenyx 502 Analogue Mixer preamp with a 3-pin XLR cable, which was also connected to a MacBook Pro laptop with Praat (Boersma & Weenink, 2006) installed. The recordings were conducted with Praat's recording function in mono, at a 44.1 kHz sampling rate and took place in a quiet room in the Department of Language and Linguistics, University of Essex, for the UK-based participants and in a quiet room at the Campion school for the Greece-based participants.

Language Background Questionnaires

In order to retrieve participants' biographical information, as well as evaluate their language background, age of onset of each language, community language, amount of daily usage and language exposure to each language, amongst other factors, the parents/ guardians of the participants were asked to complete a Language background and experience questionnaire, adapted from the Language

History Questionnaire (LHQ) of Li, Sepanski, and Zhao (2006) and Li, Zhang, Tsai, and Puls (2014) as well as the Language Experience and Proficiency Questionnaire (LEAP-Q) of Marian, Blumenfeld, and Kaushanskaya (2007). Below, there is a short overview of the questionnaires used and how the adapted version differed from the LHQ and the LEAP-Q.

In the language background questionnaire used in this study, the first part focused on collecting the parents'/ guardians' responses on their children's demographic information. There were also questions to establish the parents'/ guardians' level of education and socio-economic status (SES), as a predictor of language outcomes in children (for instance, Byers-Heinlein et al., 2020). The second, and more extended part to be completed, included a number of questions around the language background of the participants. Parents/ guardians were asked to complete how many and which languages their children spoke, as well as assess the amount of exposure to and usage for each of their children's languages, confidence in their children using each language in receptive (reading, listening) and productive (writing, speaking) skills, extended stays in foreign countries and so on. The language background questionnaire required the parents/ guardians to estimate the amount of exposure and usage of the languages in terms of percentages, similarly to the confidence levels of using each language in the different skills, which required an estimation in terms of a 1-5 Likert scale.

Compared to the LEAP-Q (Marian et al., 2007), which is designed for adults, the adapted version used in this study contained questions that would take into account that the questionnaire is completed by the participants' parents/ guardians. The LEAP-Q also assumes language dominance in one of the languages. I did not want to make this assumption while collecting parental responses, as not all children might have had the same language learning experiences and in the same settings. However, a section was left for further comments, encouraging the parents/ guardians to add any remarks they felt were not covered by the questions they had already answered. In the LEAP-Q there are also some questions on the cultures participants identify with, number of years in formal education, as well as length of stay in the US, and details for any physical, cognitive, or learning deficits. However, some of those questions would not be relevant to the research questions addressed here, therefore, they were not included in the adapted version.

Finally, the LHQ (Li et al., 2006; 2014) is an online battery that collects apart from standard demographic information, also addresses questions on the language habits of the responders in terms of interactions with family and everyday use, age of first exposure to a second language, self-assessed measures of fluency in the perceptive and productive language skills, type of second language education received, self-evaluated accented speech, code-mixing, and extended stays in different countries. The design and contents of the LHQ were considered more appropriate for adults and second language learners as was the case with the LEAP-Q, therefore their questions had to be adapted and be made relevant to be answered by the parents/ carers of the participant groups. The detailed set of adapted questionnaires can be found in Appendices 4 and 5.

Acoustic Analysis Procedure

After the recordings were obtained, the target words were isolated and manually extracted in Praat (Boersma & Weenink, 2006), followed by the identification and labelling of the individual vowels using TextGrid in Praat and visual inspection of each spectrogram and waveform. The vowels of interest were analysed in terms of F_1 (associated with the tongue height: high versus low) and F_2 frequencies (associated with tongue position: front versus back; Stephens, 1998) as well as duration. Formant measurements were automatically computed in Praat with the use of a Praat script developed to measure at the 25%, 50%, and 75% of a time window representing the stable part of each vowel (Ladefoged, 2003), and then averaged in a single measure for the analysis of monophthongs. Duration was measured by subtracting the measurement at the end of the selected window from that at the beginning.

After extracting the relevant measurements, the formant frequency values were normalised automatically following the Neary-2 method (Neary, 1978), as described in Adank, Smits and Van Hout (2004) and Adank et al. (2007). Vowel normalisations were performed using the online tool *NORM Vowel Normalisation and Plotting Suite* provided by Thomas and Kendall (2007) to control for physiological and gender differences in the formant frequency values (Peterson and Barney, 1952) and the normalised results were scaled to Hertz-like values as per Thomas and Kendall (2007).

3.4 Results

To analyse the three normalised acoustic measures obtained from the analysis (F_1, F_2, and vowel Duration), linear mixed modelling was chosen for the statistical analysis. The linear mixed models were computed in R (R Core Team, 2018), using the *lmer* (De Boeck et al., 2011) and *lmerTest* (Kuznetsova et al., 2015) packages. Candidate models were chosen by adding each factor of interest and testing whether it contributed significantly to the model fit. Before the factors were added to the model, they were tested for normality and were log transformed if necessary. Although F_1 and F_2 were also tested for normality, log transformation was not necessary as the values were already normalised using the Nearey-2 method (Nearey, 1977; Adank et al., 2004). Vowel duration was the only measure that was not normalised, so log transformation was only applied to the latter.

3.4.1 Duration

Mixed effects models for duration were developed by adding those fixed effects factors that contributed significantly to the model fit. For the model including all participant groups, those were *target vowel* (11 levels: /ʌ/, /ɒ/, /ɑ/, /æ/, /ɛ/, /ɜː/, /ɪ/, /iː/, /ʊ/, /uː/, /ɔː/), *participant group* (3 levels: Bilingual children in the UK, Bilingual children in Greece, Monolingual controls), and *task type* (2 levels: words produced in context and words produced in isolation). *Participants* and *test items* were the random effects in the models. Further models were developed by adding the factors that were relevant to bilingual participants only. Those were *Age*, *Total English Exposure*, and *Age of first exposure to English*. The factors *Percentage* of English and Greek usage per day and number of *Years* spent in Greece and the UK were added as factors too, but as they did not contribute to the model fit, they were not included in the final model for duration.

All participant groups

The presentation of results will begin with the duration plots for each vowel per participant group. Upon visual inspection of figure **??**, the bilingual group in Greece and the monolingual controls produced vowels of similar average durations, while bilingual children in the UK produced overall shorter vowels to the other two groups.

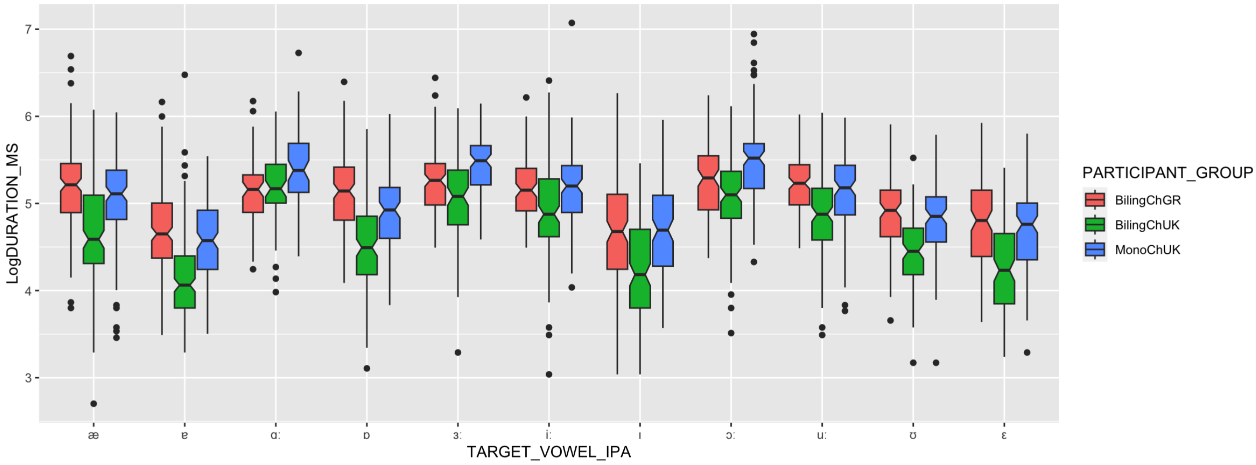


Figure 3.3: Log transformed duration (in ms) for vowel categories per participant group.

Table 3.16: *Average duration (raw values in ms) and standard deviation (SD) for vowel categories per participant group.*

Target Vowel	Bilingual Children in Greece (SD)	Bilingual Children in the UK (SD)	Monolinguals (SD)
æ	204.76 (109.24)	120.30 (71.04)	176.13 (80.53)
ɐ	121 (62.16)	69.94 (56.68)	107.20 (49.40)
ɑː	187.15 (81.27)	191.32 (66.48)	249.61 (123.80)
ɒ	185.46 (91.77)	97.31 (42.84)	145.31 (65.07)
ɜː	203.79 (86.97)	175.18 (80.90)	242.01 (78.50)
iː	187.51 (70.08)	154.15 (97.03)	193.68 (117.98)
ɪ	121.90 (73.34)	77.59 (42.70)	125.16 (68.37)
ɔː	208.16 (82.32)	189.27 (105.76)	276.63 (159.32)
uː	194.04 (64.16)	145.65 (65.91)	188.89 (75.42)
ʊ	145..74 (63.18)	95.77 (45.65)	133.93 (51.24)
ɛ	138.16 (72.56)	81.51 (47.11)	118.40 (55.12)

Following plotting of the vowels and descriptive statistics, the first linear mixed effects model was developed, as viewed in table **??**, where the fixed effects, estimates, and significance levels can be seen for the factors target vowel, participant group, and task type. The following baselines were chosen: for factor *Target Vowel* the baseline was /ʌ/ as being in the most central position compared to the rest; for factor *Participant Group* the baseline was Monolingual Children UK as this was the control group, and for factor *Task Type* the baseline was (words produced in) *Context* as it was expected that vowels produced in context would differ from those produced in isolation.

As it can be viewed from the table, all vowels were produced significantly longer than /ʌ/, with the exception of /ɪ/($p = .75$), /ʊ/ ($p = .15$), and /ɛ/ ($p = .44$), which did not differ significantly. Task type was also significant: vowels incorporated in words produced in isolation were significantly longer to those produced in context ($p < .01$). Finally, significant differences in vowel duration were observed between the Bilingual group in the UK and monolingual controls ($p < .01$) as opposed to the comparison between Bilingual children in Greece and monolingual controls who did not differ significantly in terms of duration ($p = .76$).

Table 3.17: *The fixed effects (Target vowel, Participant groups, and Task type) and the Target vowel * Participant group interaction in the linear mixed model for Duration (ms). The baseline for Target vowel is /ʌ/, for Participant groups is Monolingual children UK, and for Task type is (words produced in) Context. ("***" $p < 0.001$, "**" $p < 0.01$, "*" $p < 0.05$, "." $p < 0.1$, " " $p < 1$)*

	Dependent variable:	
	LogDuration (ms)	
Target Vowel æ	0.652***	(0.137)
Target Vowel ɑː	0.701***	(0.158)
Target Vowel ɒ	0.366***	(0.129)
Target Vowel ɜː	0.679***	(0.127)
Target Vowel iː	0.645***	(0.132)
Target Vowel ɪ	−0.041	(0.126)
Target Vowel ɔː	0.858***	(0.136)
Target Vowel uː	0.541***	(0.124)
Target Vowel ʊ	0.265**	(0.133)
Target Vowel ɛ	0.103	(0.135)
Participant Group Bilingual Children GR	0.073	(0.085)
Participant Group Bilingual Children UK	−0.377***	(0.084)
Task Type Isolation	0.071***	(0.013)
Intercept	−0.371***	(0.107)
Observations	3,743	
Log Likelihood	−1,684.130	
Akaike Inf. Crit.	3,402.261	
Target Vowel æ : Participant Group Bilingual Children GR	0.080	(0.059)
Target Vowel ɑː : Participant Group Bilingual Children GR	−0.351***	(0.076)
Target Vowel ɒ : Participant Group Bilingual Children GR	0.139**	(0.062)
Target Vowel ɜː : Participant Group Bilingual Children GR	−0.278***	(0.064)
Target Vowel iː : Participant Group Bilingual Children GR	0.013	(0.064)
Target Vowel ɪ : Participant Group Bilingual Children GR	−0.065	(0.062)
Target Vowel ɔː : Participant Group Bilingual Children GR	−0.301***	(0.063)
Target Vowel uː : Participant Group Bilingual Children GR	−0.025	(0.062)
Target Vowel ʊ : Participant Group Bilingual Children GR	0.030	(0.064)
Target Vowel ɛ : Participant Group Bilingual Children GR	0.011	(0.063)
Target Vowel æ : Participant Group Bilingual Children UK	0.042	(0.060)
Target Vowel ɑː : Participant Group Bilingual Children UK	0.206**	(0.081)
Target Vowel ɒ : Participant Group Bilingual Children UK	0.051	(0.063)
Target Vowel ɜː : Participant Group Bilingual Children UK	0.095	(0.067)
Target Vowel iː : Participant Group Bilingual Children UK	0.207***	(0.062)
Target Vowel ɪ : Participant Group Bilingual Children UK	0.003	(0.063)
Target Vowel ɔː : Participant Group Bilingual Children UK	0.139**	(0.064)
Target Vowel uː : Participant Group Bilingual Children UK	0.197***	(0.063)
Target Vowel ʊ : Participant Group Bilingual Children UK	0.150**	(0.065)
Target Vowel ɛ : Participant Group Bilingual Children UK	−0.051	(0.064)
Intercept	−0.367***	(0.108)
Observations	3,743	
Log Likelihood	−1,618.894	
Akaike Inf. Crit.	3,313.787	

The interaction between target vowels and participant group was also tested and was also significant ($p < .01$), as per table **??**. Significant interactions were observed for the vowels /ɑː/, ($p < .01$), /ɒ/, ($p = .02$), /ɜː/, ($p < .01$), /ɔː/, ($p < .01$) and bilingual group in Greece. For the interaction between target vowel and bilingual group in the UK, significant interactions were observed for the vowels /ɑː/, ($p = .01$), /iː/, ($p < .01$), /ɔː/, ($p < .01$), /uː/ , ($p < .01$), and /ʊ/, ($p = .02$)

Post hoc pairwise comparisons were carried out using Estimated Marginal Means (*emmeans* R package; Lenth, 2021) with TukeyHSD corrections, as reported in Table **??**. Bilingual children in Greece did not produce vowels significantly differently to Monolingual controls ($t(50) = -0.70$ $p = 0.76$). However, such was the case for the comparison between the UK-based bilingual children group and the Monolingual controls, as the bilingual group produced longer vowels ($t(50) = 4.23$, $p < 0.01$). The comparison between the two bilingual groups also demonstrated that the UK-based group produced longer vowels compared to the Greece-based one ($t(50) = 5.08$, $p < 0.01$).

Table 3.18: *Post hoc pairwise comparisons for participant groups. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

Contrasts	Estimate	SE	t *(df)*	p
Monolingual Children UK - Bilingual Children GR	-0.0598	0.0850	-0.703 (50)	0.7628
Monolingual Children UK - Bilingual Children UK	0.3561	0.0840	4.237 (50.1)	0.0003
Bilingual Children GR - Bilingual Children UK	0.4159	0.0814	5.089 (50)	<.0001

The final factor that was explored in the linear mixed model for duration for all participants was Age, which did not improve the model fit ($p = .70$) as well as the Age * Group interaction which was significant for the Bilingual group in Greece ($p = .04$), as per Table **??**.

Table 3.19: *The fixed effects (Target vowel, Participant groups, Task type, and Age) and the Participant group * Age interaction in the linear mixed model for Duration (ms). The baseline for Target vowel is /ʌ/, for Participant groups is Monolingual children UK, and for Task type is (words produced in) Context. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	LogDuration (ms)	
Target Vowel æ	0.642^{***}	(0.134)
Target Vowel ɑː	0.687^{***}	(0.155)
Target Vowel ɒ	0.329^{***}	(0.127)
Target Vowel ɜː	0.720^{***}	(0.124)
Target Vowel iː	0.633^{***}	(0.129)
Target Vowel ɪ	−0.038	(0.123)
Target Vowel ɔː	0.833^{***}	(0.133)
Target Vowel uː	0.508^{***}	(0.122)
Target Vowel ʊ	0.508^{***}	(0.122)
Target Vowel ɛ	0.101	(0.132)
Participant Group Bilingual Children GR	0.077	(0.081)
Participant Group Bilingual Children UK	-0.399^{***}	(0.082)
Task Type Isolation	0.075^{***}	(0.013)
Age	0.009	(0.024)
Participant Group Bilingual Children GR : Age	-0.088^{**}	(0.043)
Participant Group Bilingual Children UK : Age	-0.058^{*}	(0.035)
Intercept	-0.360^{***}	(0.104)
Observations	3,743	
Log Likelihood	−1,750.722	
Akaike Inf. Crit.	3,541.445	

Bilingual children

Following modelling for all participant groups, further models were developed for the bilingual participants only including the factors that were applicable to those. The factors *Place of residence (Greece and the UK), Age of English Onset, Years of English Exposure in Greece and the UK, and percentage of daily English and Greek usage* were included as fixed effects in models exploring the bilingualism background variables. Factors that contributed significantly to the fit of the first model were the target vowel, participant group, and task type, as was the case in the models for all participant groups, as well as the vowel * group interaction as per table **??**.

Table 3.20: *Fixed effects (Target vowel, Participant groups, and Task type) and the Participant group * Target vowel interaction in the linear mixed model for Duration (ms) for Bilingual participants only. The baseline for Target vowel is /ʌ/, for Participant groups is Bilingual Children UK, and for Task type is (words produced in) Context. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	Log Duration (ms)	
Target Vowel æ	0.628^{***}	(0.167)
Target Vowel ɑː	0.584^{***}	(0.209)
Target Vowel ɒ	0.362^{**}	(0.161)
Target Vowel ɜː	0.684^{***}	(0.157)
Target Vowel iː	0.737^{***}	(0.163)
Target Vowel ɪ	−0.0002	(0.158)
Target Vowel ɔː	0.794^{***}	(0.169)
Target Vowel uː	0.539^{***}	(0.154)
Target Vowel ʊ	0.212	(0.158)
Target Vowel ɛ	0.024	(0.164)
Participant Group Bilingual Children GR	0.403^{***}	(0.071)
Task Type Isolation	0.100^{***}	(0.016)
Target Vowel æ : Participant Group Bilingual Children GR	0.038	(0.060)
Target Vowel ɑː : Participant Group Bilingual Children GR	-0.508^{***}	(0.081)
Target Vowel ɒ : Participant Group Bilingual Children GR	0.108^{*}	(0.063)
Target Vowel ɜː : Participant Group Bilingual Children GR	-0.321^{***}	(0.066)
Target Vowel iː : Participant Group Bilingual Children GR	-0.164^{**}	(0.066)
Target Vowel ɪ : Participant Group Bilingual Children GR	−0.056	(0.063)
Target Vowel ɔː : Participant Group Bilingual Children GR	-0.334^{***}	(0.065)
Target Vowel uː : Participant Group Bilingual Children GR	-0.169^{***}	(0.062)
Target Vowel ʊ : Participant Group Bilingual Children GR	−0.071	(0.068)
Target Vowel ɛ : Participant Group Bilingual Children GR	0.063	(0.066)
Intercept	-0.715^{***}	(0.119)
Observations	2,584	
Log Likelihood	−1,313.323	
Akaike Inf. Crit.	2,660.645	

In addition, a model exploring the factors *Place of Residence, Age of English onset, length and amount of exposure to and usage of English and Greek* as fixed effects was developed, as it can be seen in Table **??**. The factors Place of Residence ($p <$ .01) as well as the number of years being exposed to English ($p <$ .01) and Greek (p < .01) all contributed significantly to the model fit, as opposed to the percentage of English ($p =$ .21) and Greek usage ($p =$ .21), which did not.

Table 3.21: *Fixed effects Target Vowel, Participant group, Place of Residence, Age of English onset, Years of English exposure in Greece and the UK, and Percentage of daily English usage in the linear mixed model for Duration (ms) for Bilingual participants only. The baseline for Participant groups is Bilingual Children UK and for Place of Residence is UK. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	Log Duration (ms)	
Target Vowel æ	0.629***	(0.167)
Target Vowel ɑː	0.600***	(0.209)
Target Vowel ɒ	0.378**	(0.161)
Target Vowel ɜː	0.693***	(0.157)
Target Vowel iː	0.759***	(0.163)
Target Vowel ɪ	0.005	(0.158)
Target Vowel ɔː	0.798***	(0.169)
Target Vowel uː	0.548***	(0.154)
Target Vowel ʊ	0.230	(0.158)
Target Vowel ɛ	0.054	(0.164)
Participant Group Bilingual Children GR	0.554***	(0.157)
Place of Residence UK	−0.554***	(0.157)
Age of Onset to English	−0.036	(0.038)
Years of English exposure in UK	−0.049***	(0.017)
Years of English exposure in GR	−0.068***	(0.024)
Percentage of daily English usage	−0.003	(0.003)
Percentage of daily Greek usage	0.003	(0.003)
Intercept	−0.097	(0.227)
Observations	2,584	
Log Likelihood	−1,334.279	
Akaike Inf. Crit.	2,817.842	

3.4.2 F_1

All participant groups

The second variable that was explored as part of this analysis was F_1 for each vowel per participant group. As with duration, mixed effects modelling was also chosen for the analysis of F_1, to account for both fixed and random effects. The same process as with duration was followed in terms of choosing the appropriate models: first, a global model was developed, which included the fixed effects factors that would be relevant to all participant groups. Those were *target vowel, participant group,* and *task type. Participants* and *test items* were added as random effects. The results from the global model will be presented first, before presenting the model for the bilingual children only.

Figure **??** shows the F_1 values for each vowel per participant group. Following visual inspection, there is variability for (/ɜː/ and /ɪ/) and (/Oː/, especially for the bilingual group in Greece. Otherwise, the F_1 frequencies seem homogeneous across participant groups.

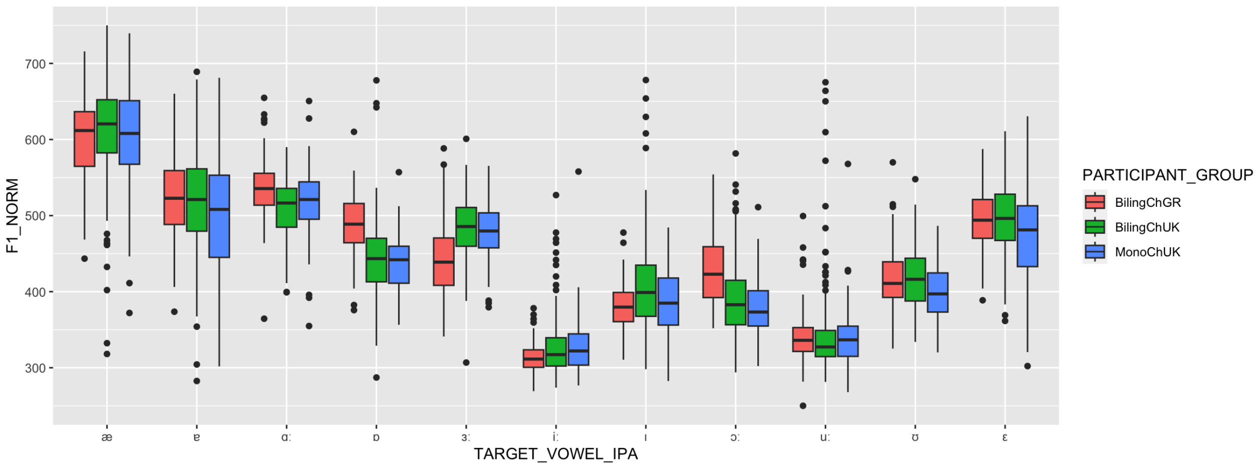


Figure 3.4: Normalised F_1 values (Hz) (F_1_NORM))for vowel categories per participant group. *"BilingChGR" stands for Bilingual children in Greece, "BilingChUK" stands for Bilingual Children in the UK and "MonoChUK" stands for Monolingual Children in the UK. "TARGET_VOWEL_IPA" stands for the target vowels examined in this study, in IPA transcription.*

Table 3.22: *Normalised F_1 values(Hz) and standard deviation (SD) for vowel categories per participant group.*

Target Vowel	Bilingual Children in Greece (SD)	Bilingual Children in the UK (SD)	Monolinguals (SD)
æ	1151.72 (167.69)	1206.42 (184.80)	1115.50 (169.06)
ɐ	956.65 (155.30)	949.57 (191.33)	852.01 (104.35)
ɑː	990.05 (151.43)	930.09 (104.96)	887.32 (124.15)
ɒ	862.74 (103.97)	758.26 (151.51)	698.49 (107.29)
ɜː	728.96 (141.55)	858.54 (108.99)	804.85 (101.28)
iː	401.12 (64.56)	454.25 (132.96)	419.87 (88.35)
ɪ	573.28 (88.49)	662.21 (176.39)	574.73 (111.89)
ɔː	697.38 (125.68)	623.76 (159.67)	546.94 (90.67)
uː	473.87 (101.51)	505.01 (195.79)	444.63 (97.82)
ʊ	671.88 (117.37)	686.11 (121.73)	606.28 (93.02)
ɛ	873.42 (111.79)	895.23 (145.88)	778.61 (150.29)

Following plotting of the vowels, the first linear mixed effects model was developed, as viewed in table **??**, where the fixed effects, estimates, and significance levels can be seen for the factors target vowel, participant group, and task type. The baseline factors were the same as in the Duration models: (/ʌ/ for factor *Target Vowel*, Monolingual Children UK for factor *Participant Group*, and [words produced in] *Context* for factor *Task Type*).

The results from the first model for all participants, showed that all vowels, apart from ɑː, ($p = .14$), differed from the baseline vowel /ʌ/, as per Table **??**. Task type was also significant: F_1 frequencies of vowels incorporated in words produced in context were significantly lower to those produced in isolation ($p < .01$). Participant group was another factor that contributed to the model fit: bit the bilingual group in Greece ($p < .01$) and the bilingual group in the UK ($p < .01$) differed significantly from the monolingual group, which was set as the baseline. Following the mixed effects model including the fixed effects *target vowel, participant group,* and *task type*, I tested for the interaction between target vowels and participant group, for which there was a significant main effect ($p < .01$). Significant interactions were observed for all vowels but /ɑː/, ($p = .65$), /ʊ/, ($p = .13$), and /ɛ/, ($p = .88$) and bilingual group in Greece. For the interaction between target vowel and bilingual group in the UK, significant interactions were observed only for the vowels /ɑː/, ($p = .01$), and /ɜː/, ($p = .05$), seen in table **??**.

Table 3.23: *The fixed effects (Target vowel, Participant groups, and Task type) in the linear mixed model for F_1 (Hz). The baseline for Target vowel is /ʌ/, for Participant groups is Monolingual children UK, and for Task type is (words produced in) Context. (“***” p < 0.001, “**” p < 0.01, “*” p < 0.05, “.” p < 0.1, “ ” p < 1)*

	Dependent variable:	
	F_1 (Normalised) (Hz)	
Target Vowel æ	85.986***	(8.110)
Target Vowel ɑː	8.532	(9.828)
Target Vowel ɒ	−57.988***	(7.975)
Target Vowel ɜː	−49.786***	(7.709)
Target Vowel iː	−190.880***	(7.970)
Target Vowel ɪ	−124.798***	(7.655)
Target Vowel ɔː	−116.447***	(8.204)
Target Vowel uː	−170.709***	(7.465)
Target Vowel ʊ	−106.183***	(8.098)
Target Vowel ɛ	−32.328***	(7.961)
Participant Group Bilingual Children GR	10.034**	(4.778)
Participant Group Bilingual Children UK	11.442**	(4.737)
Task Type Isolation	9.232***	(1.701)
Intercept	503.125***	(6.274)
Observations	3,743	
Log Likelihood	−19,943.680	
Akaike Inf. Crit.	39,921.350	
Target Vowel æ : Participant Group Bilingual Children GR	−29.556***	(8.096)
Target Vowel ɑː : Participant Group Bilingual Children GR	−4.585	(10.334)
Target Vowel ɒ : Participant Group Bilingual Children GR	23.248***	(8.433)
Target Vowel ɜː : Participant Group Bilingual Children GR	−69.089***	(8.717)
Target Vowel iː : Participant Group Bilingual Children GR	−40.916***	(8.704)
Target Vowel ɪ : Participant Group Bilingual Children GR	−33.822***	(8.471)
Target Vowel ɔː : Participant Group Bilingual Children GR	23.368***	(8.646)
Target Vowel uː : Participant Group Bilingual Children GR	−21.957***	(8.423)
Target Vowel ʊ : Participant Group Bilingual Children GR	−12.946	(8.721)
Target Vowel ɛ : Participant Group Bilingual Children GR	1.263	(8.619)
Target Vowel æ : Participant Group Bilingual Children UK	−10.461	(8.142)
Target Vowel ɑː : Participant Group Bilingual Children UK	−26.916**	(10.857)
Target Vowel ɒ : Participant Group Bilingual Children UK	−10.788	(8.616)
Target Vowel ɜː : Participant Group Bilingual Children UK	−17.206*	(9.077)
Target Vowel iː : Participant Group Bilingual Children UK	−15.538*	(8.455)
Target Vowel ɪ : Participant Group Bilingual Children UK	3.682	(8.524)
Target Vowel ɔː : Participant Group Bilingual Children UK	−2.797	(8.645)
Target Vowel uː : Participant Group Bilingual Children UK	−6.815	(8.512)
Target Vowel ʊ : Participant Group Bilingual Children UK	−3.467	(8.901)
Target Vowel ɛ : Participant Group Bilingual Children UK	10.116	(8.733)
Intercept	495.913***	(7.013)
Observations	3,743	
Log Likelihood	−19,764.800	
Akaike Inf. Crit.	39,603.600	

However, there were no significant significant differences in vowels' F_1 values between either group. Specifically, the the two bilingual groups (p = .99) did not differ significantly between them, nor did the bilingual group in Greece and monolingual controls (p = .12) or the UK-based groups: Bilinguals in the UK and Monolingual controls (p = .09) as per table **??**.

Table 3.24: *Post hoc pairwise comparisons for participant groups. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

Contrasts	Estimate	SE	t *(df)*	p
Monolingual Children UK - Bilingual Children GR	-9.748	4.86	-2.008 (50.4)	0.1207
Monolingual Children UK - Bilingual Children UK	-10.270	4.82	-2.131 (51.5)	0.0935
Bilingual Children GR - Bilingual Children UK	-0.522	4.66	-0.112 (51.1)	0.9931

Another factor that was explored in the linear mixed model for duration for all participants was Age, which improved the model fit (p < .01) as well as the Age * Group interaction, which was not significant for either group (Bilingual group in Greece (p = .35); Bilingual group in the UK (p = .53)), so it was not considered in subsequent models. The model including the Age factor and the Age * Group interaction can be viewed in Table **??**.

Table 3.25: *The fixed effects (Target vowel, Participant groups, Task type, and Age) and the Participant group * Age interaction in the linear mixed model for F_1 (Hz). The baseline for Target vowel is /ʌ/, for Participant groups is Monolingual children UK, and for Task type is (words produced in) Context. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	F_1 (Normalised) (Hz)	
Target Vowel æ	86.129***	(8.121)
Target Vowel ɑː	8.624	(9.838)
Target Vowel ɒ	−57.843***	(7.985)
Target Vowel ɜː	−49.450***	(7.718)
Target Vowel iː	−190.851***	(7.981)
Target Vowel ɪ	−124.631***	(7.665)
Target Vowel ɔː	−116.137***	(8.214)
Target Vowel uː	−170.558***	(7.474)
Target Vowel ʊ	−105.754***	(8.108)
Target Vowel ɛ	−32.230***	(7.971)
Participant Group Bilingual Children GR	11.748***	(3.413)
Participant Group Bilingual Children UK	−0.946	(1.515)
Task Type Isolation	9.258***	(1.699)
Age	−4.753***	(0.674)
Participant Group Bilingual Children GR : Age	−1.694	(1.840)
Participant Group Bilingual Children UK : Age	−0.058*	(0.035)
Intercept	502.512***	(5.798)
Observations	3,743	
Log Likelihood	−19,922.200	
Akaike Inf. Crit.	39,884.410	

Following developing a global model for all the participants, subsequent models were developed for the factors that were relevant to the bilingual participant groups. Those were *place of residence, age of first exposure to English, years of exposure to English and Greek*, and *percentage of daily usage of Greek (L1)* and *English (L2)*. The results for the bilingual groups are presented in the next section.

Bilingual children

Following modelling for all participant groups, further models were developed for the bilingual participants only including the factors that were applicable to those. The factors *Place of residence (Greece and the UK), Age of English Onset, Years of English Exposure in Greece and the UK, and percentage of daily English and Greek usage* were included as fixed effects in models exploring the bilingualism background variables. The baselines, similarly to previous analyses were /ʌ/, *bilingual children in the UK*, and (words produced in) *context*.

The results from the first model showed that for bilingual children, all vowels, apart from ɑː, ($p = .38$), differed from the baseline vowel /ʌ/, as it can be viewed in table **??**. Task type also contributed significantly to the model: words produced in context elicited lower F_1 values than those in isolation, ($p = < .01$). Participant group did not contribute to the model fit, as the Greece-based bilingual group did not differ from the baseline ($p = .76$), as per Table **??**. Finally, the Target Vowel * Participant Group interaction was significant for all vowels but /ʊ/ ($p = .22$) and /ɛ/ ($p = .21$).

Table 3.26: *Fixed effects (Target vowel, Participant groups, and Task type) and the Participant group * Target vowel interaction in the linear mixed model for F_1 (Hz) for Bilingual participants only. The baseline for Target vowel is /ʌ/, for Participant groups is Bilingual Children UK, and for Task type is (words produced in) Context. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	F_1 (Normalised) (Hz)	
Target Vowel æ	85.510^{***}	(8.759)
Target Vowel ɑː	9.913	(11.386)
Target Vowel ɒ	-51.666^{***}	(8.703)
Target Vowel ɜː	-62.231^{***}	(8.503)
Target Vowel iː	-195.748^{***}	(8.657)
Target Vowel ɪ	-126.026^{***}	(8.357)
Target Vowel ɔː	-109.960^{***}	(8.921)
Target Vowel uː	-171.267^{***}	(8.232)
Target Vowel ʊ	-105.415^{***}	(8.730)
Target Vowel ɛ	-27.816^{***}	(8.774)
Participant Group Bilingual Children GR	−1.390	(4.569)
Task Type Isolation	6.655^{***}	(2.058)
Target Vowel æ : Participant Group Bilingual Children GR	-20.014^{***}	(7.711)
Target Vowel ɑː : Participant Group Bilingual Children GR	20.572^{**}	(10.412)
Target Vowel ɒ : Participant Group Bilingual Children GR	33.335^{***}	(8.120)
Target Vowel ɜː : Participant Group Bilingual Children GR	-52.774^{***}	(8.606)
Target Vowel iː : Participant Group Bilingual Children GR	-25.843^{***}	(8.468)
Target Vowel ɪ : Participant Group Bilingual Children GR	-38.423^{***}	(8.128)
Target Vowel ɔː : Participant Group Bilingual Children GR	25.552^{***}	(8.453)
Target Vowel uː : Participant Group Bilingual Children GR	-15.956^{**}	(8.092)
Target Vowel ʊ : Participant Group Bilingual Children GR	−10.501	(8.727)
Target Vowel ɛ : Participant Group Bilingual Children GR	−10.566	(8.559)
Intercept	511.908^{***}	(6.727)
Observations	2,584	
Log Likelihood	−13,676.780	
Akaike Inf. Crit.	27,405.560	

In addition, a model exploring the factors *Place of Residence, Age of English onset, length and amount of exposure to and usage of English and Greek* as fixed effects was developed, as it can be seen in Table **??**. The number of years being exposed to English ($p < .01$) and Greek ($p < .01$) were the only factors that contributed to the model fit. Place of residence ($p = .74$), percentage of English ($p = .18$) and Greek usage ($p = .29$), and Age of Onset of English ($p = .08$) did not.

Table 3.27: *Fixed effects Target Vowel, Participant group, Place of Residence, Age of English onset, Years of English exposure in Greece and the UK, and Percentage of daily English usage in the linear mixed model for F_1 (Hz) for Bilingual participants only. The baseline for Participant groups is Bilingual Children UK and for Place of Residence is UK. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	F_1 (Normalised) (Hz)	
Target Vowel æ	85.921***	(8.953)
Target Vowel ɑː	10.850	(11.612)
Target Vowel ɒ	−50.934***	(8.888)
Target Vowel ɜː	−61.598***	(8.675)
Target Vowel iː	−194.381***	(8.832)
Target Vowel ɪ	−125.448***	(8.533)
Target Vowel ɔː	−108.856***	(9.110)
Target Vowel uː	−170.487***	(8.402)
Target Vowel ʊ	−103.536***	(8.901)
Target Vowel ɛ	−26.396***	(8.942)
Participant Group Bilingual Children GR	0.554***	(0.157)
Age of English onset	−3.090*	(1.802)
Place of Residence UK	1.537	(4.783)
Years of English exposure in UK	−5.544***	(0.870)
Years of English exposure in GR	−4.383***	(1.239)
Percentage of daily English usage	−0.191	(0.143)
Percentage of daily Greek usage	0.153	(0.145)
Intercept	566.666***	(11.905)
Observations	2,584	
Log Likelihood	−13,775.300	
Akaike Inf. Crit.	27,588.600	

3.4.3 F_2

All participant groups

The final variable to be analysed was F_2 for each vowel per participant group. Upon visual inspection of figure **??**, variability is observed in the F_2 productions of vowels /ɪ/, /iː/, /ɛ/, and /ʊː/ for all participant groups.

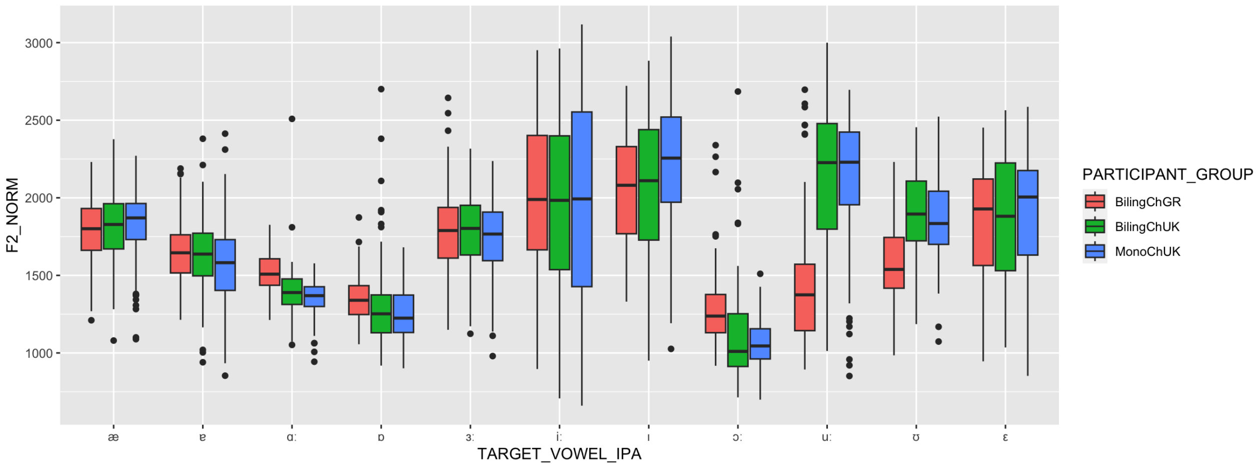


Figure 3.5: Normalised F_2 values (Hz) (F_2_NORM) for vowel categories per participant group. *"BilingChGR" stands for Bilingual children in Greece, "BilingChUK" stands for Bilingual Children in the UK and "MonoChUK" stands for Monolingual Children in the UK. "TARGET_VOWEL_IPA" stands for the target vowels examined in this study, in IPA transcription.*

Table 3.28: *Normalised F_2 values(Hz) and standard deviation (SD) for vowel categories per participant group.*

Target Vowel	Bilingual Children in Greece (SD)	Bilingual Children in the UK (SD)	Monolinguals (SD)
æ	1792.27 (182.19)	1814.80 (204.52)	1813.56 (112.76)
ɐ	1643.96 (180.06)	1632.98 (214.80)	1575.28 (155.81)
ɑː	1514.07 (134.77)	1405.04 (201.12)	1346.00 (132.68)
ɒ	1357.08 (147.35)	1306.17 (262.37)	1262.56 (163.77)
ɜː	1798.17 (257.27)	1790.79 (227.15)	1727.17 (254.03)
iː	2045.47 (260.73)	1980.11 (355.74)	1997.12 (246.48)
ɪ	2043.55 (246.44)	2071.49 (236.06)	2233.75 (282.45)
ɔː	1246.74 (226.21)	1096.59 (202.73)	1052.63 (150.88)
uː	1446.36 (271.82)	2148.39 (213.22)	2131.25 (229.74)
ʊ	1560.35 (253.26)	1900.52 (256.96)	1867.90 (287.44)
ɛ	1863.66 (334.55)	1876.93 (274.85)	1879.89 (201.52)

As for the previous variables, a mixed effects linear model was developed for the factors that were applicable to all participant groups *(*tagret vowel; baseline /ʌ/, participant group; baseline Monolingual children in the UK, and task type; baseline words produced in context), including the responses from the bilingual participants in Greece and the UK and monolingual controls. From the model output, it was found that all vowels (/æ/, /ɑː/, /ɒ/, /ɜː/, /iː/, /ɪ/, /ɔː/, /uː/, /ʊ/ and /ɛ/) differed significantly in terms of backness (measured by F_2) to the baseline vowel /ʌ/. However, neither group differed to the monolingual controls in their productions (Bilingual group in Greece, $p = .15$; Bilingual group in the UK, $p = .61$), nor did the formant frequency values differ depending on the task type ($p = .88$), as per table **??**. Apart from the main effects, the Target vowel* Participant group interaction was also explored in the model. Significant interactions were only observed for vowels /æ/ ($p = .01$), /ɪ/ ($p < .01$), /ɔː/ ($p < .01$), /uː/ ($p < .01$), /ʊ/ ($p < .01$), /ɛ/ ($p = .03$) and the Bilingual group in Greece, whilst the only significant interaction for the bilingual group in the UK was for /ɪ/ ($p < .01$), as viewed in Table **??**.

Table 3.29: *The fixed effects (Target vowel, Participant groups, and Task type) and the Target Vowel * Participant group interaction in the linear mixed model for F_2 (Hz). The baseline for Target vowel is /ʌ/, for Participant groups is Monolingual children UK, and for Task type is (words produced in) Context. ("***" $p < 0.001$, "**" $p < 0.01$, "*" $p < 0.05$, "." $p < 0.1$, " " $p < 1$)*

	Dependent variable:	
	F_2 (Normalised) (Hz)	
Target Vowel æ	170.442***	(52.954)
Target Vowel ɑː	−221.307***	(64.336)
Target Vowel ɒ	−348.259***	(52.139)
Target Vowel ɜː	138.280***	(50.427)
Target Vowel iː	333.866***	(52.093)
Target Vowel ɪ	475.214***	(50.050)
Target Vowel ɔː	−508.038***	(53.610)
Target Vowel uː	260.228***	(48.834)
Target Vowel ʊ	190.309***	(52.937)
Target Vowel ɛ	230.550***	(52.054)
Participant Group Bilingual Children GR	−45.367	(32.172)
Participant Group Bilingual Children UK	16.126	(31.896)
Task Type Isolation	−1.642	(11.389)
Intercept	1,642.930***	(41.395)
Observations	3,743	
Log Likelihood	−27,031.210	
Akaike Inf. Crit.	54,096.430	
Target Vowel æ : Participant Group Bilingual Children GR	−126.597**	(52.123)
Target Vowel ɑː : Participant Group Bilingual Children GR	89.239	(66.565)
Target Vowel ɒ : Participant Group Bilingual Children GR	17.520	(54.304)
Target Vowel ɜː : Participant Group Bilingual Children GR	21.618	(56.136)
Target Vowel iː : Participant Group Bilingual Children GR	−40.916***	(8.704)
Target Vowel ɪ : Participant Group Bilingual Children GR	−258.901***	(54.550)
Target Vowel ɔː : Participant Group Bilingual Children GR	125.265**	(55.661)
Target Vowel uː : Participant Group Bilingual Children GR	−810.278***	(54.264)
Target Vowel ʊ : Participant Group Bilingual Children GR	−398.137***	(56.143)
Target Vowel ɛ : Participant Group Bilingual Children GR	−116.137**	(55.508)
Target Vowel æ : Participant Group Bilingual Children UK	−77.404	(52.425)
Target Vowel ɑː : Participant Group Bilingual Children UK	−12.198	(69.992)
Target Vowel ɒ : Participant Group Bilingual Children UK	−22.943	(55.482)
Target Vowel ɜː : Participant Group Bilingual Children UK	15.752	(58.461)
Target Vowel iː : Participant Group Bilingual Children UK	−81.102	(54.435)
Target Vowel ɪ : Participant Group Bilingual Children UK	−215.465***	(54.883)
Target Vowel ɔː : Participant Group Bilingual Children UK	−37.897	(55.663)
Target Vowel uː : Participant Group Bilingual Children UK	−73.308	(54.842)
Target Vowel ʊ : Participant Group Bilingual Children UK	−32.698	(57.312)
Target Vowel ɛ : Participant Group Bilingual Children UK	−73.043	(56.247)
Intercept	1,572.171***	(46.744)
Observations	3,743	
Log Likelihood	−26,671.070	
Akaike Inf. Crit.	53,416.140	

Post hoc comparisons were performed to explore the differences between participant groups, however, there were no significant significant differences in vowels' F_2 values between either group. Specifically, the the two bilingual groups ($p = .12$) did not differ significantly between them, nor did the bilingual group in Greece and monolingual controls ($p = .34$) or the UK-based groups: Bilinguals in the UK and Monolingual controls ($p = .86$) as per table **??**.

Table 3.30: *Post hoc pairwise comparisons for participant groups. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

Contrasts	Estimate	SE	t *(df)*	p
Monolingual Children UK - Bilingual Children GR	45.4	32.2	1.410 (49.6)	0.3436
Monolingual Children UK - Bilingual Children UK	-16.1	31.9	-0.506 (50.4)	0.8690
Bilingual Children GR - Bilingual Children UK	-61.5	30.8	-1.994 (50)	0.1242

Another factor that was explored in the linear mixed model for duration for all participants was Age, which improved the model fit ($p < .01$). What was also explored was the Age * Group interaction, which was not significant for either group (Bilingual group in Greece ($p = .56$); Bilingual group in the UK ($p = .86$)), so it was not considered in subsequent models. The model including the Age factor and the Age * Group interaction can be viewed in Table **??**.

Table 3.31: *The fixed effects (Target vowel, Participant groups, Task type, and Age) and the Participant group * Age interaction in the linear mixed model for F_1 (Hz). The baseline for Target vowel is /ʌ/, for Participant groups is Monolingual children UK, and for Task type is (words produced in) Context. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	F_2 (Normalised) (Hz)	
Target Vowel æ	169.935***	(52.533)
Target Vowel ɑː	−222.383***	(63.874)
Target Vowel ɒ	−348.985***	(51.744)
Target Vowel ɜː	136.766***	(50.057)
Target Vowel iː	334.333***	(51.697)
Target Vowel ɪ	474.132***	(49.674)
Target Vowel ɔː	−508.780***	(53.198)
Target Vowel uː	259.534***	(48.476)
Target Vowel ʊ	188.282***	(52.536)
Target Vowel ɛ	229.941***	(51.664)
Participant Group Bilingual Children GR	−53.111*	(28.319)
Participant Group Bilingual Children UK	32.219	(28.344)
Task Type Isolation	−1.841	(11.384)
Age	22.387***	(5.555)
Participant Group Bilingual Children GR : Age	−8.888	(15.315)
Participant Group Bilingual Children UK : Age	2.186	(12.578)
Intercept	1,645.322***	(39.632)
Observations	3,743	
Log Likelihood	−27,021.390	
Akaike Inf. Crit.	54,078.780	

Bilingual children

The development of models for bilingual participants included factors that were hypothesised to affect the children's F_2 productions. Those, similarly to previous models were *Age of English onset, Place of Residence, Years of English exposure in Greece and the UK as well as percentage of daily English and Greek usage.* The first model for the Bilingual groups only included the factors *Target vowel, Participant group,* and *Task type*as fixed effects and the Target Vowel * Participant group interaction, as per Table **??**. As it can be viewed, all vowels differed significantly from the baseline /ʌ/. Bilingual children in Greece were significantly different to those in the UK (p = .03), however, F_2 was not affected by whether words were produced in isolation or in context (p = .51). The interactions between vowels /ɔː/ (p < .01), /uː/ (p < .01) and /ʊ/ (p < .01) and the Bilingual group in Greece were also significant.

Table 3.32: *The fixed effects (Target vowel, Participant groups, and Task type) and the Target vowel * Participant Group interaction in the linear mixed model for F_2 (Hz) for bilingual participants only. The baseline for Target vowel is /ʌ/, for Participant groups is Bilingual children UK, and for Task type is (words produced in) Context. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	F_2 (Normalised)	
Target Vowel æ	163.119***	(57.435)
Target Vowel ɑː	−176.201**	(74.567)
Target Vowel ɒ	−332.683***	(57.034)
Target Vowel ɜː	166.143***	(55.678)
Target Vowel iː	310.532***	(56.707)
Target Vowel ɪ	392.163***	(54.758)
Target Vowel ɔː	−478.494***	(58.453)
Target Vowel uː	141.696***	(53.912)
Target Vowel ʊ	118.131**	(57.163)
Target Vowel ɛ	211.781***	(57.443)
Participant Group Bilingual Children GR	−62.287**	(30.009)
Task Type Isolation	−8.714	(13.273)
Target Vowel æ : Participant Group Bilingual Children GR	−48.619	(47.452)
Target Vowel ɑː : Participant Group Bilingual Children GR	20.572**	(10.412)
Target Vowel ɒ : Participant Group Bilingual Children GR	36.277	(49.992)
Target Vowel ɜː : Participant Group Bilingual Children GR	3.996	(52.967)
Target Vowel iː : Participant Group Bilingual Children GR	46.654	(52.151)
Target Vowel ɪ : Participant Group Bilingual Children GR	−40.178	(50.016)
Target Vowel ɔː : Participant Group Bilingual Children GR	163.580***	(52.030)
Target Vowel uː : Participant Group Bilingual Children GR	−733.994***	(49.801)
Target Vowel ʊ : Participant Group Bilingual Children GR	−361.281***	(53.748)
Target Vowel ɛ : Participant Group Bilingual Children GR	−41.612	(52.720)
Intercept	1,686.451***	(42.645)
Observations	2,584	
Log Likelihood	−18,579.380	
Akaike Inf. Crit.	37,284.470	

Finally, a model exploring the factors *Place of Residence, Age of English onset, length and amount of exposure to and usage of English and Greek* as fixed effects was developed, as it can be seen in Table **??**. Age of Onset of English did not contribute to the model fit (p = .74), nor did the years of English exposure in Greece (p = .13), and the percentage of daily English (p = .68) and Greek usage (p = .66). The only factors that contributed to the model fit were the place of residence (p = .03) and the years of English exposure in the UK (p < .01).

Table 3.33: *Fixed effects Target Vowel, Participant group, Place of Residence, Age of English onset, Years of English exposure in Greece and the UK, and Percentage of daily English usage in the linear mixed model for F_2 (Hz) for Bilingual participants only. The baseline for Participant groups is Bilingual Children UK and for Place of Residence is UK. ("***" $p < 0.001$, "**" $p < 0.01$, "*" $p < 0.05$, "." $p < 0.1$, " " $p < 1$)*

	Dependent variable:	
	F_1 (Normalised) (Hz)	
Target Vowel æ	163.119^{***}	(57.435)
Target Vowel ɑː	-176.201^{**}	(74.567)
Target Vowel ɒ	-332.683^{***}	(57.034)
Target Vowel ɜː	166.143^{***}	(55.678)
Target Vowel iː	310.532^{***}	(56.707)
Target Vowel ɪ	392.163^{***}	(54.758)
Target Vowel ɔː	-478.494^{***}	(58.453)
Target Vowel uː	141.696^{***}	(53.912)
Target Vowel ʊ	118.131^{**}	(57.163)
Target Vowel ɛ	211.781^{***}	(57.443)
Participant Group Bilingual Children GR	0.554^{***}	(0.157)
Age of English onset	−5.437	(16.662)
Place of Residence UK	64.802^{**}	(31.415)
Years of English exposure in UK	24.440^{***}	(7.375)
Years of English exposure in GR	10.369	(6.870)
Percentage of daily English usage	−0.498	(1.239)
Percentage of daily Greek usage	−0.594	(1.364)
Intercept	566.666^{***}	(11.905)
Observations	2,584	
Log Likelihood	−13,775.300	
Akaike Inf. Crit.	27,588.600	

3.4.4 Vowel Spaces

Following the acoustical analysis of F_1, F_2, and vowel duration for all groups, the total acoustic space area was also calculated by using the total convex hull area as defined by all the vowels per participant group, using the R package "phonR" (McCloy, 2016). The acoustic vowel spaces for the three participant groups can be viewed in Figure **??**.

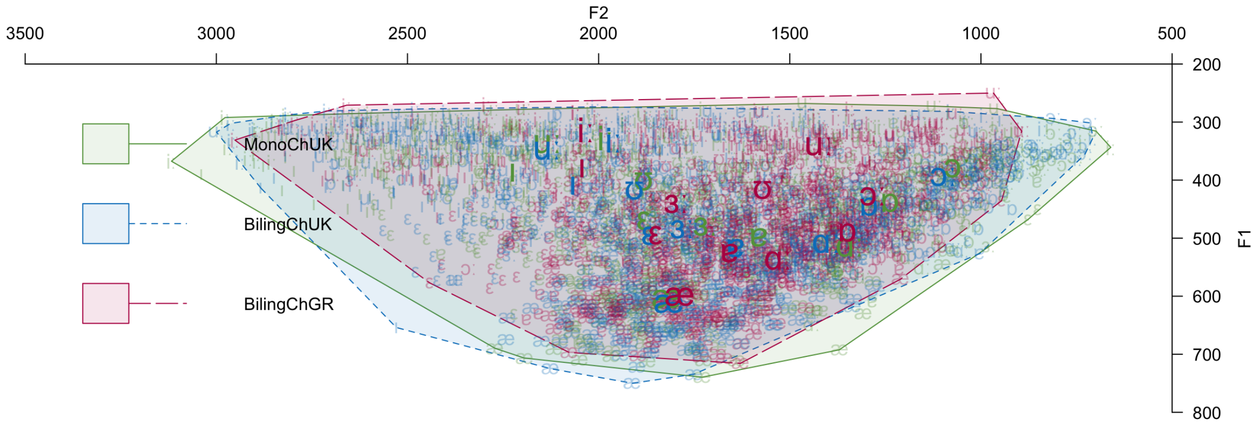


Figure 3.6: Vowel space area (in ERB^2) for Bilingual children in the UK and in Greece and Monolingual controls

From the figure as well as from the obtained results it can be noted that the vowel productions of the Monolingual controls occupied the largest acoustic space area (772896ERB^2), followed by the Bilingual group in the UK whose vowels occupied the second largest area (741331ERB^2). The smallest vowel space area was occupied by the Bilingual group in Greece (653020ERB^2).

3.5 Discussion

The present study aimed to add to the existing bilingual speech production literature by focusing on the effects of linguistic environment on bilingual children's productions. However, in contrast with previous work, in which individual vowel contrasts were examined (for instance, see Amengual-Watson & Chamorro, 2015; Amengual-Watson, 2011; Ramon-Casas, 2009; Simonet, 2010), I examined most of the BE monophthongs and did not limit the study to individual vowel pairs. To examine the effect of the linguistic environment, I tested Greek-English bilingual children growing up in Greece and the UK. I chose the language pair of Greek and English as a particularly interesting language combination, due to the differences the two systems have in terms of number of vowel phonemes, vowel categories, and contrasts. I tested the vowel productions of bilingual children by developing three structured and semi-structured elicitation tasks to which children needed to respond by naming pictures replacing the words containing the test items. The participant responses were audio recorded and analysed in terms of three acoustic characteristics: formant frequencies of the first two formants (F_1 and F_2) and vowel duration, as both are acoustic correlates of BE vowels (Ainswroth, 1972; Hillenbrand et al., 2000), as well as the vowel space area for each group.

So far in this paper, I have discussed that phonemes are represented in both monolingual and bilingual infants since the very first months in development. Specifically, the period between 6 and 12 months is crucial, as during that period infants have been found to be able to identify the vowels of their native language (Polka & Werker, 1994; Werker & Tees, 1984); later on, at 9 months they employ their ability to identify statistical regularities in the input to perceive the consonants of their native language inventory (Gervain & Mehler, 2010; Kuhl, 1992). Using the consonant and vowel information, infants at 12 months are also able to recognise words they are exposed to frequently (Jusczyk & Aslin, 1995), while this developmental pattern holds true both for monolingual and bilingual infants.

Perceiving and learning such regularities early in life has positive implications in terms of the production performance of monolingual and bilingual infants. Enhanced speech perception early in life has been associated with a larger vocabulary size both in monolingual and in bilingual children (for instance, Conboy et al., 2005; Molfese, 2000; Tsao et al., 2004). Later in life, as infants grow older and input from each language is predicted to differ both between caregivers at home and from the environment children grow up in (schooling, friends' circles, dominant language in the community), can lead to one language being more dominant, which will inevitably influence speech production in each language (Meisel, 2016). For instance, Chondrogianni (2018) identifies factors such as age of onset to the L2, quantity and quality of input, length of exposure, education, and the family's socio-economic status as important predictors in the language development of successive child bilinguals.

The speech productions of the children in this study were were analysed in terms of three acoustic characteristics. First of all, I analysed duration, as it is a correlate of BE vowels both in perception and production, unlike in SMG, where contrasts in durations are not identified amongst phonemes. I also analysed the values of the first two formants (F_1 and F_2) to compare how BE vowels were produced in terms of height and backness. I finally compared the acoustic vowel spaces of the three participant groups. The statistical analysis was done by means of mixed linear models, one for each variable of interest (duration, F_1, and F_2), while separate models were developed for all participant groups, which included only the factors that were relevant to all children (target vowel, participant group, context), and bilingual groups, also adding factors that could have influenced bilingual vowel production (age, percentage of usage of each language daily, length of exposure to English). Overall, I found that the bilingual group in Greece produced BE vowels in a similar manner to monolingual controls in terms of duration, while bilingual participants in the UK produced overall shorter vowels. For F_1, neither bilingual group differed in their vowel productions in terms of height, as both performed as monolingual controls did. However, as greater variability was observed in some vowels, this needs to be accounted for. Finally, F_2 was not different across groups either, as both bilingual groups did not perform differently to monolingual controls.

Different factors need to be considered while interpreting the bilingual results.

Factors such as the context vowel tokens are produced in, age, years of exposure to English in Greece or the UK, total years of English exposure, and percentage of daily usage of each language were hypothesised to affect the bilingual productions for each group. When words were produced in isolation, this helped elicit longer vowels than when the same words were produced in context. This is attributed to the fact that connected, spontaneous speech is faster, while less attention is given to enunciation, as it would be the case for words produced in isolation (Moyer, 2004).

When it comes to age, this was also found to be a significant factor when vowel duration was examined, especially for bilinguals in the UK, who produced shorter vowels. Another important factor that needs to be taken into account is the country bilinguals grow up in and the ambient language spoken there. The ambient language is relevant in terms of the amount of exposure bilingual children growing up in the UK and in Greece receive in each of their languages, which can have implications on which language they are more dominant in. The findings of this study are contrary to the hypotheses formulated earlier: it was hypothesised that UK-based bilinguals, who were reported more dominant in English in the language background questionnaires, as this is the language they are exposed to most during the day, through school, friend interactions, media, and the ambient language spoken would perform more similar to monolinguals in the UK, who are also exposed to the same input, accent, environment, language spoken in the community and through day-to-day interactions.

In contrast, it was hypothesised that the group deviating from monolingual norms would be the Greece-based one, which was reported to have the opposite exposure pattern. This was reflected on being exposed to English in all aspects of day-to-day life, apart from schooling and interactions with friends; the instances that Greece-based bilinguals were exposed to Greek were the ambient language, their caregivers and other family members, childcare, if available, and the media. However, this hypothesis was not confirmed in the experimental findings, as the bilingual group in Greece performed as monolinguals in the UK did.

Apart from the amount of exposure and dominance in the language of their environment, it is also worth highlighting that the two systems differ significantly in terms of the size of their inventories and the organisation of the vowels in each, which is another factor to be considered in the interpretation of the results. To summarise, SMG has a small five-vowel system, while the amount of BE vowels is almost triple. Apart from merely size, the BE vowel system is characterised by tense and lax vowel contrasts that do not exist in SMG.

3.6 Conclusions

This study involved testing two groups of early English-Greek bilingual children in their BE vowel productions. The groups had shared profiles both when it comes to demographics and to language background profile: both groups were exposed to both Greek and English from an early age, if not birth, they were schooled in English and had daily input in both their languages. However, they differed in the amount of exposure to each language, as one group was based in Greece and the other in the UK, so the ambient language was different in each case. This translated to a difference in language dominance: one group was judged as Greek-dominant by the parent responses to language background questionnaires and the other as English-dominant. This difference in exposure to the ambient language also caused differences in the bilinguals' vowel productions.

The Greece-based group had, in most cases, produced vowel tokens that resembled the native productions, which was not the case for the UK-based group. Specifically, the vowels that did not share acoustic characteristics in the two languages were produced in a native-like manner by the first group, unlike those which did, and their productions did not resemble that of the monolinguals; in fact, new categories were created that shared some acoustic characteristics (either height or degree of backness) to English. We attributed this observation to the fact that the Greek-dominant bilinguals were filtering the non-dominant language vowels through SMG and were able as a result to perceive those vowels that did not share acoustic characteristics to their dominant language more successfully. Successful perceptual discrimination would in turn suggest a more successful production, findings which are in line with the predictions of the PAM and SLM models. For the vowels that shared some acoustic characteristics in both SMG and BE, the Greece-based bilingual group demonstrated the production of new, merged categories that did not resemble the characteristics of either of the languages in question. This observation can also be explained through PAM: those exemplars that do not differ in two languages are harder to perceive and therefore produce in a native-like manner.

On the other hand, the BE-dominant monolinguals demonstrated productions that were similar to the native ones in one of the acoustic characteristics, either height or backness. Drawing again from the predictions of the PAM and the SLM, vowels who share acoustic characteristics between the first and the second language, in this work between the dominant and the non-dominant language, are not perceived as distinct categories, therefore they are produced either as new categories or as categories that have merged characteristics across the two languages, which is what we observed here too. Although the PAM and the SLM have largely been used as models to explain second language acquisition, especially for late acquirers in the case of the SLM, their proposals are also found to be relevant when examining early bilinguals with different dominant languages.

Chapter 4

The Acquisition of New Phonemic Contrasts by L2 Learners: Greek Native Speakers' Productions of British English Tense-Lax Vowels

Abstract

Learning phonemes in a new language can be an effortful task for second language learners, especially those who are required to learn phonemic categories or contrasts that differ significantly between their native and second language, as previous research has shown. A number of factors have been seen to impact on L2 speech production, such as the languages' inventory sizes, degree of similarity of phonemic categories across language pairs, and amount of experience in the L2, all of which were be explored in this study. The language pair of Greek and Standard Southern British English (SSBE) was chosen as an example of two systems which differ not only in terms of the number of vowels existing in each, but also in terms of phonemic contrasts and number of phonemic categories. 19 native Greek L2 learners of BE took part in a production study which examined acoustic

correlates of vowel categories in BE (F_1, F_2, vowel Duration). It was found that L2 learners were able to produce vowel categories in SSBE successfully, as their productions did not deviate from monolingual norms in terms of vowel height and backness. This was also evident in the vowel spaces of L2 Learners and monolingual controls, which did not differ in size or vowel distribution. In terms of vowel duration, no significant differences were observed between the productions of L2 Learners and Monolingual controls either. The findings are discussed in terms of the two models of L2 speech production (SLM, Flege, 1992; 1995; 2005 and PAM, Best & Strange, 1992; Best, 1995; Tyler, 2019) as well as with regards to the implications of the size of their native language phonemic inventory.

4.1 Introduction

The study of second language (L2) speech production has been a core topic in second language acquisition (SLA) research since its beginnings. Areas of study include, but are not limited to accented speech, ultimate attainment, L2 proficiency, the effect of two phonological systems, and age-related effects for which a number of theories have been developed in order to interpret the observations and experimental findings of various studies.

Starting historically, one of the most influential theories is the "Critical Period Hypothesis" (Lenneberg, 1967), according to which it is hard or impossible to master one's native language (L1) past a specific maturational stage post puberty. The theory was initially used to explain late acquirers' impaired communicative ability in the L1, based on observations of the language performance of feral children and children who were deprived of exposure to their native language till a later stage of their lifespan (Curtiss, Fromkin, Krashen, Rigler, & Rigler, 1974). Soon after its introduction though, the model was also used to explain some observations in L2 performance, in that following a detection of a sharp decline in late acquirers' linguistic abilities, the model was used as an exploratory factor for phenomena such as accented speech and poor performance in L2 grammar and morphosyntax, unlike performing in a native-like manner, regardless the amount of exposure received in that language.

Another theory making predictions of L2 performance, specifically speech, is the Speech Learning Model (SLM) (for instance, see Flege, 1992; 1995; 2005), who questioned the existence of a critical period as the sole predictor of the difference in speech production between L2 speaking children, who had exposure to the L2 since early in life, and adults, who were exposed to the L2 later. The SLM was developed in an attempt to establish a relationship between sound perception and production in adults, not because of the existence of age effects, but because of the presupposition that late first exposure to an L2 means that the L1 phonemic categories have already been established when L2 exposure occurs, therefore, it is harder for adults to master the L2 pronunciation in a native-like manner. The third theory making predictions for L2 speech is the Perceptual Assimilation Model (PAM; for instance: Best & Strange, 1992; Best, 1995; Tyler, 2019), which is concerned with the perceptual assimilation of L2 categories to L1 ones depending on their similarities or differences across languages.

In this introduction, I will discuss two models of L2 speech, mentioned earlier, as well as the Critical Period Hypothesis and address the implications of the theories' predictions in the study of L2 pronunciation and accented speech in adult L2 learners. I will also explore whether the size and organisation of the native language inventory can have an influence on the productions of phonemic categories in the L2. Later in the section, I will be comparing the vowel inventories of Standard Modern Greek and British English, which will be used as examples of two inventories differing in phonetic categories and vowel features, before presenting the research questions, methodology, and findings of the present study.

4.1.1 L2 Learners' speech perception and production

Speech Learning Model

The first model to be discussed as an influential model of making predictions related to L2 speech production is the Speech Learning Model (SLM; among others: Flege 1992; 1995; 2005). A model used to explain the varying outcomes in the speech output of adult L2 speaker, especially those exposed to an L2 later in life, the SLM highlights the relationship between perception and production of individual phonemes in two languages, as well as makes predictions regarding which phonemes could be easily learnable by or pose difficulties to L2 speakers, based on their similarity and dissimilarity with native language categories.

The general rule regarding phonemic categories according to the model is the more similar L1 and L2 categories are, the more difficult it is for learners to perceive fine phonetic differences that help form new categories in the L2. This might lead to "merged" categories in the output of L2 speakers, with shared characteristics between the two languages, but not exclusive resemblance to the categories of either language (Flege, 1995). Alternatively, if there is large perceptual distance between L1 and L2 phonemes, the two sounds are perceived as different, which leads to easier category formation in the L2. This, in turn leads to the formation of distinct L1 and L2 categories for those phonemes. When it comes to production, "merged" L1-L2 categories are observed when L1 and L2 sounds share properties of both native and non-native categories, while native-like production is achieved when L1 and L2 categories are perceived as different. Category formation is key to the model as well as to the learning of an L2, as it is important for learners to know both what the categories of the language being learnt are, and to have access to the properties of those categories. Achieving both can help with the successful perception of fine acoustic details of L2 phonemes, which can lead to their accurate production, as accurate categorical perception is a prerequisite for accurate production of those categories (Flege, 2016).

The model is guided by several principles and accompanying hypotheses, summarised below. One of the principles relates to categorical perception of L2 phonemes, which can be accurate, given accurate, sufficient, and quality input, which derives from several years of exposure to a naturalistic L2-speaking setting; this is usually the current country of residence of the L2 speakers in question (Flege, 2005). Although primarily a speech production model, the role of phonemic perception is also highlighted through its principles as the two modes are intertwined: perceptual representations of specific L2 sounds are stored in long-term memory; those representations directly affect L2 production (Flege, 2016). The SLM makes two further claims; first, the ability to form new phonetic categories in the L1 as well as any other process involved in L1 speech acquisition, remains intact across the lifespan. When an L2 is also acquired, the two processes run in parallel, however, by the time the L2 is introduced -if this occurs later in life- the L1 phonetic categories and accompanying processes are already more advanced.

Category formation in the L2 is predicted to occur as follows: a new category will be formed for an L2 sound if speakers of that language perceive a great dissimilarity between the L2 sound and the closest equivalent in their native language (Flege, 1995). Therefore, new categories are possible to be formed if L2 learners are able to identify perceptual differences between their first and second language. However, if an L2 sound is perceived as too similar to its L1 counterpart, a new category is not possible to be formed in the L2: in that case, the L1 and the L2 categories tend to merge into a single one, with shared L1-L2 characteristics, by applying the mechanism of "equivalence classification" (Flege, 1995, p.239), which suggests that perceptually similar sounds are filtered through a single phonetic category, therefore are perceived in a similar manner. Nevertheless, as the ability to acquire L2 categories remains intact throughout the lifespan and it is possible even for late acquirers, it is possible that the L1 and L2 categories co-exist in a common space and inevitably influence one another. In fact, the influence of native and non-native categories on one another can be such that the acoustic-phonetic space of L2 learners is reconstructed to a shared space including both languages (Leather & James, 1996). However, the hypothesis that L1 and L2 categories co-exist, can have implications on the production of the phonetic categories themselves in either language: a shared space would not exclude interference between the two languages and possibly transfer of characteristics, which would also cause either language's categories to deviate from monolingual norms (Kartushina, Frauenfelder, & Golestani, 2016).

I already mentioned earlier how the model predicts a very close relationship between perception and production, in that in order to achieve accurate production, it is necessary for L2 speakers to demonstrate accurate perception of phonemic contrasts, which affects phonetic category formation. Based on this assumption, the model makes predictions of how L2 sounds would be produced, judging by the phonetic categories that have been formed. For instance, the L2 sounds for which new categories have been formed will be produced more accurately and closer to a native speaker's production, as opposed to those for which there does not exist a new L2 phonetic category. For instance, category formation in SSBE for the /ɪ/-/iː/ and /ʊ/-/uː/ vowel contrasts is expected to be difficult for L2 Learners whose native language only has one vowel representation for a high front or a high back vowel. Therefore, a "merged" category would be expected following the predictions of the SLM. Equally, vowels for which a phonemic category exists both in the L1 and the L2 are expected to be perceived accurately and the production of the phoneme would not be expected to deviate from monolingual norms.

Category formation is also seen to be affected by age: although the process might remain intact throughout the lifespan both for the L1 and the L2, according to

Flege (1995), adults might have an advantage in forming L2 categories successfully as opposed to children, as early in life the latter are yet to establish the phonetic categories of their native language, something that late L2 learners would be more advanced into.

However, one more prediction is made for similar and dissimilar vowels in relation to age, that phonetically similar vowels between the L1 and the L2 will be produced well in the early stages of L2 acquisition, but poorly at the later stages and vice versa for phonetically dissimilar vowels (Flege, 2005). I would attribute the hypothesis to the fact that in the early stages of L2 learning, when the L1 phonetic norms have already been well-established, but not those of the L2, L2 learners are inexperienced in perceiving the acoustic differences between L1 and L2 sounds, so they might be identifying those sounds as similar and not creating new vowel categories for them but instead are filtering them through their L1. As experience increases with exposure to the L2 sounds, the learners are able to discriminate fine phonetic differences and apply them in their speech, sounding more native-like.

For instance, Flege, MacKay, and Meador (1999) found that native-like perception and production of Canadian-English vowel contrasts is possible when there is a significant amount of exposure to and usage of the L2, following a vowel intelligibility task, during which native English speakers were asked to rate the L2 speakers' productions as well as a categorical discrimination task for perception. It is worth noting here though, that the participants in question were considered highly experienced (or in Flege et al.'s (1999) words "early and late bilinguals", for instance see p. 2973) of varying degrees, depending on the age of L2 acquisition, while acquisition occurred exclusively in a naturalistic setting, after the subjects emigrated to Canada.

The revised version of the model (SLM-r; Flege, Aoyama, & Bohn, 2020) suggests initial mapping of L2 phonetic categories through L1 categories, a process which occurs “subconsciously and automatically” (p. 2). This would suggest that when inexperienced learners hear an L2 sound early in the acquisition process, they would map it as a sound which resembles one of their L1 . Following the principles of the model’s earlier versions, as experience with the L2 increases, so does the input received, which would help with discerning the perceptual distance between categories and establish new ones, based on their similarity or dissimilarity to L1 phonetic categories. However, what is not clear from the models’ predictions, is how much input, experience, and usage is necessary before new categories are established, and how long it would take L2 learners to discern perceptual differences of L2 categories successfully.

Most of the research in support of the model, to date, has been carried out with “experienced” (Flege, Yeni-Komshian, & Liu, 1999) or “highly proficient” (MacKay, Flege, & Imai, 2006) L2 speakers, at times, even considered “bilinguals” (Flege et al., 1999). For instance, Flege, Yeni-Komshian, and Liu (1999) in their study of native Korean, L2 speakers of American English, who were tested in terms of morphosyntax and speech production performance. The participants were considered “experienced” L2 speakers, by having emigrated to the US between ages 1 and 23 and having lived there for at least 15 years. Testing involved ratings of their perceived degree of foreign accent by native English speakers post a sentence production task, while performance in knowledge of English morphosyntax was assessed through acceptability ratings in a Grammaticality Judgement Task (GJT). Findings revealed that age of acquisition, which coincided with the age of first exposure to the L2, was a strong predictor for the degree of foreign accent: those participants who had an early age of arrival were rated as sounding more native-like and, as the age of arrival increased, so did the degree of perceived foreign accent. As per the predictions of the SLM, the amount of exposure to an immersion setting- which coincided with decades of living in the foreign country-had an effect on the L2 performance, both in terms of pronunciation and accuracy in the use of morphosyntax.

The same group of experienced Korean-English speakers was later tested by Yeni-Komshian, Flege and Liu (2000), who also examined speech production performance and morphosyntactic accuracy ratings in GJTs. In line with the findings of the previously mentioned study, those participants with an early arrival to the US (up to age 5) were rated as performing native-like in the speech production tasks. A degree of transfer of the L2 to their L1, causing them to sound foreign-like in Korean in terms of pronunciation, was also observed. As it had been suggested in the SLM, increased experience to the L2 is a necessary condition in forming new phonetic categories, which made it possible for native Koreans to produce native-like utterances and score highly in acceptability ratings. The fact that a degree of reverse transfer from the L2 to the L1 was also noted could be attributed to the fact that both languages' phonetic categories coexist in a shared space, causing the two systems to interact.

The ability to learn new phonetic categories, even those that are notoriously hard for some L2 speakers, has also been documented in experienced Japanese learners' productions of the English /l/-/r/ contrast (Flege et al., 2020), however, as in previous studies, this presupposes extensive exposure to the L2 in a native language setting, given once again, several years of continuous exposure and input to the L2. Aoyama and Flege (2011) suggest that even for adults who arrived to the English-speaking country (US) post 18 years, there needs to be an average of 2 years of "full time English input" (calculated as the proportion of English use multiplied by the Length of Residence), at least for Japanese adults, in order to become sensitive to the difference between /l/ and /r/ and identify goodness-of-fit between the English liquids and the Japanese category.

The fact that early exposure to the L2 seems to contribute to native-like performance, might be considered as evidence towards the existence of a Critical Period in L2 acquisition, a theory which will be reviewed later in this section in more detail. However, AOA does not seem to be the sole predictor of native-like performance in the SLM. Emphasis is also placed on the amount of input received, as well as, and more importantly, the quality of input, given that L2 learning occurred in immersion settings. The fact that there are bidirectional influences in the speech production performance too, mostly suggests an interaction of the two language systems, rather than maturational constraints in the learning of the L2 (MacKay, Flege, & Imai, 2006).

Although the SLM is a prominent model used to make predictions for speech production in L2 learning, the experimental findings and hypotheses seem to be applicable to highly experienced learners, with several years of exposure to the L2, while learning occurs at an immersion setting. Even for late learners, who are also included in the model, the amount of exposure and input are the primary predictors to their performance in speech production tasks. Piske (2007) has made reference to the application of the model's principles to the foreign language classroom, as not all L2 learning occurs at a naturalistic setting, by establishing the conditions that need to be applied in order for L2 learners to achieve high-proficiency, or even native-like speech performance. Those are summarised under four categories; high quality input, intensive exposure to the L2, pronunciation training, and early age of L2 exposure. The reality in a foreign language classroom however, frequently tends to differ: although exposure might start at an early age, the amount of input received is often limited to the compulsory lesson hours, while lessons are most often taught by qualified teachers of the L2, who are not native speakers though. Experience and practice with the language are also limited to the foreign language classroom, and learners rarely have the opportunity to practise outside lesson times. Taking those factors into account, it would be interesting to explore how the predictions of the model hold true for L2 learners who combine experience to an L2 both from an instructed and a naturalistic setting.

Perceptual Assimilation Model

The second model making predictions on the acquisition of L2 phonemes depending on the similarity between L1 and L2 categories is the Perceptual Assimilation Model (PAM; Best, McRoberts, & Sithole, 1988; Best & Strange, 1992; Best, 1995). Primarily a model of speech perception, its propositions could also be used to make predictions in terms of speech production. Similarly to the SLM, the PAM bases its predictions to those learners who are acquiring the L2 at an immersion setting, where the L2 is dominant. The Perceptual Assimilation Model of Second Language Speech Learning followed (PAM-L2; Best & Tyler, 2007; Tyler, 2019), to account for the performance in perceptual abilities of those learners, who, without previous experience to the L2, achieve high communicative performance in a predominantly L1 environment. This would apply to learners who are exposed to an L2 via instruction at a country where that L2 would not be dominantly spoken.

Another similarity between the SLM and the PAM(-L2) is that the perceptual system between the learners' L1 and L2 functions at a common space, which implies interaction between L1 and L2 phonological categories and how well those categories account for discriminating L2 contrasts. For instance, the PAM predicts that L2 speech sounds tend to be perceptually assimilated into the closest L1 sound in one of the following three ways: L2 sounds can be classified as "Categorised" if they are either good or bad exemplars of L1 sounds, as "Uncategorised", when L2 sounds are completely dissimilar to any L1 sound, so the former will fall somewhere between L1 sound categories, and as "Non-assimilated", for non-linguistic speech sounds that do not resemble any L1 phonemes. However, membership to a phonetic category is not the sole factor predicting assimilation. What is also important is the degree of similarity or contrast between native and non-native sounds (Best & Strange, 1992), as well as the relationship between the categories in the system (Tyler, 2019).

An important property in the PAM is discrimination accuracy, as this determines whether and how well assimilation of phonemic contrasts between two languages may occur (Flege, 2003; Tyler, 2019). Predictions regarding perceptual assimilation and discrimination accuracy include the following: if two non-native phonemes are assimilated to different L1 categories, discrimination is expected to be excellent, as a contrast between L2 phonemes is perceived. If two L2 phonemes are assimilated to a singe L1 category, then enough contrast between the L2 phonemes might not be detected to support their discrimination, but some sensitivity to goodness-of-fit in relation to L1 categories might be present. Having one L2 phoneme being a more “acceptable” token for the L1 category than the other predicts good assimilation, as some discrimination ability is still detected. In the case that there is no goodness-of-fit to the L1 category from either L2 phoneme, then discrimination is predicted to be poor. Finally, phonemes for which one is categorised and the other uncategorised, discrimination of contrasts is possible and is even predicted to be very good.

Applying the predictions of the PAM to the acquisition of new L2 categories, discrimination and categorisation of new L2 phonemes occurs depending on the degree of contrast and assimilation to L1 phonemic categories. New category acquisition in the L2 may improve discrimination performance when the contrast assimilation type changes, for instance, when category goodness assimilation becomes two-category assimilation (Tyler, 2019). To exemplify, when each L2 phoneme in a contrast is perceived as a different L1 category (what was termed “two-category assimilation” in the PAM and excellent discrimination of categories was predicted), existing knowledge of L1 categories facilitates discrimination. In case L1-L2 categories differ, perceived differences may also become sharper for L2 learners with experience over time. If L1-L2 versions occupy different areas of a shared phonetic space, then it is possible for learners to establish separate L1-L2 phonemic categories. However, if L1-L2 versions are perceptually close and no substantial difference between the two is identified, then learners might establish a single phonetic category for new L2 phonemes with shared L1-L2 characteristics (see Tyler, 2019 for a detailed account of possible outcomes for the perception of new L2 phonemes depending on how well they are categorised/uncategorised).

To summarise, the PAM has been used to predict perception of non-native phonetic categories based on whether/ how well they are assimilated to native language sounds. Its extension (PAM-L2) uses the original hypotheses to draw predictions for the perception of new L2 phonemes. The predictions of both models are applicable to the perceptual patterns demonstrated by experienced speakers of two languages which do not share the same phonemic/ phonetic categories. Using the models' principles we can draw implications on how well L1-L2 categories can be assimilated by L2 learners of language pairs that either share phonetic categories or have different ones. As accurate production of phonemic categories and contrasts presupposes accurate perception (Flege, 2016), the models' predictions can be used to draw conclusions of L2 category production, by hypothesising how L2 categories are assimilated.

Critical Period Hypothesis

The third theory I will be discussing in this section is Lenneberg's (1967) Critical Period Hypothesis (CPH), which was initially formulated in order to explain maturational constraints in the acquisition of one's native language, drawing from observations of those who were deprived of exposure to language at an early age, for instance, feral or congenitally deaf children. The theory stipulates the existence of a specific period during puberty, after which, failing early exposure to the native language, it is very hard, if not impossible to perform as typically developing individuals with L1 exposure since the initial stages of life. The hypothesis started getting increasingly popular in SLA research too, following observations of the varying outcomes in the performance of early and late L2 acquirers. In order though to explain the gradual decline in the performance of late L2 acquirers as opposed to a sharp drop, as the CPH suggests, the "maturational state hypothesis" was formulated (Johnson & Newport, 1989). The hypothesis predicts a gradual decline in cognitive abilities and L2 performance after age 7.

In this section, I am going to review some of the studies in support of the existence of a maturational stage in L2 acquisition, past which native-like performance is hard to achieve. Johnson and Newport (1989) for instance, drew from the preliminary hypothesis that a language can be acquired during a specific age period extending from infancy till puberty by hypothesising that young children would be more successful in learning an L2 when compared to adults trying to achieve the same task. Their hypothesis was examined with a group of native Korean and Chinese L2 speakers of English with varying degrees of age of first exposure and amounts of exposure to the L2, who took part in GJTs and tasks testing metalinguistic awareness of grammatical structures. The findings seemed to support the hypothesis of "the earlier the better", as the participants' age of first exposure to English correlated with the tasks' accuracy scores: L2 learners who were exposed to the L2 earlier in life and prior to puberty performed better to those exposed post-puberty. Johnson and Newport's (1989) observations for late arrivals did not correlate with other factors, such as length of exposure to the L2, motivations, and so on.

DeKeyser (2000), not only tested the existence of a critical period in L2 acquisition, but also of the "Fundamental Difference hypothesis" (FDH; Bley-Vroman, 1989), by replicating the study by Johnson and Newport (1989). According to the FDH, when implicit language learning takes place, for instance in the naturalistic setting of an L2-speaking country, adult learners cannot only rely on innate mechanisms for successful language learning. They also need to employ higher-level skills, such as problem-solving. In that case, adults are able to demonstrate a very good performance in L2 aptitude tests, comparable to that of early acquirers. However, these skills only seem to be employed by adults with high analytical abilities and not by everyone, this is why according to DeKeyser (2000), adult performance might vary, so the existence of the CP should be disregarded. In fact, following the replication of the study by Johnson and Newport (1989), DeKeyser (2000) concluded that there is indeed a CP, at least in terms of learning the grammar of an L2, with the "cut-off" period being after age 6 and definitely before age 17, which is in line with what Lenneberg (1967) had suggested.

Apart from L2 learners' performance in metalinguistic awareness and morphosyntax, some studies have also focused on the effects of age of acquisition on the L2 phonology (for instance, Asher & García, 1969; Munro, Flege, & MacKay, 1996; Oyama, 1976; and Tahta, Wood, & Lowenthal, 1981, among others). The common finding amongst the previous studies was a positive correlation between the age of first L2 exposure and and performance in L2 speech production, in that early L2 acquirers performed better in the set tasks by sounding native-like, regardless of the amount of L2 input received. On the surface, it seems like the earlier L2 learners are exposed to the L2 the better it is, as after the hypothesised CP, L2 acquirers' abilities in speech production tasks would decline. Although in theory, early acquirers seem to be favoured by the CP, an important consideration to make is the fact that late acquirers have more developed cognitive abilities than early ones, which helps them at the initial stages of acquiring the L2, when a faster rate is observed. If we consider though that the "target" in L2 learning is ultimate attainment, early acquirers would be at an advantage in the long run, as they would be more likely to reach that stage as opposed to adults.

However, although a decline in performance and the possibility for late learners not to reach a native-like stage might be a common observation for findings in support of a CP, I would argue that there are a few things to consider. First of all, the predictions of the CP seem to hold true in isolated skills. For instance, evidence for the advantage of the age of L2 acquisition is not consistent for every skill; native-like attainment might be observed in isolated skills even within the same group of learners, but not all at the same time making it imperative to establish multiple “cut-off” ages. The complexity of each skill and cognitive load required to acquire each are factors that would suggest multiple CPs. Other factors, also affecting L2 acquisition need to be taken into account too, not solely age. Those can be, for example, motivation, engagement with the local community, amount of usage of the L2, or years of exposure (Moyer, 2004). The advantage of early acquirers regarding ultimate attainment could also be attributed to their cumulative experience with the L2, which could be much longer than those of adults.

In addition to other factors what is disregarded by the existence of a CP (apart from possibly in Johnson & Newport, 1989) is previous experience with the L2, for instance at an instructed setting. In the existing literature, what has been considered as “experienced” L2 learners were those that had spent several years in an L2-dominant country, but had no previous exposure to the L2, prior to emigrating there, which held particularly true for studies of pronunciation attainment. The final thing to consider is that research supporting or providing evidence against the existence of a CP have been testing the two extremes of the continuum. Those in support of the existence of a CP have been looking at ultimate attainment, giving early acquirers an overall advantage- I have already mentioned though that this advantage might not be due to their age, but due to their total amount of exposure to the L2. Those against the existence of a CP have been looking at the early stages of adult L2 acquisition, where an overall advantage has been observed.

However, this advantage could be attributed to a number of factors apart from age: for instance, mature learners employing different strategies when learning an L2, increased motivation, a fully developed system in their L1. In order to consider the existence of a specific maturational stage in development past which learning an L2 is more effortful and does not necessarily lead to native-like performance, we would need to give answers to some further questions: first of all, how can we define ultimate attainment, at which stage and after how many years of continuous exposure can we start talking about ultimate attainment, how much exposure to the L2 is enough and can be considered adequate in order to be able to safely conclude whether there are age effects in the learning of an L2? In this paper, I have acknowledged the CPH as an influential theory making predictions for L2 performance as well as a hypothesis for which there is still ongoing debate. However, as the participants in this study were exposed to the L2 at an immersion setting far beyond the hypothesised Critical Period and the only “early learning” they had received was at an instructed setting, I will not be discussing any possible age effects.

4.1.2 Phonological Inventory Size

In the previous section, I demonstrated that a number of theories have made predictions regarding L2 learners’ spoken productions. A recurring theme in those theories was the fact that phonetic categories of the L1 can play a prime role in the categorisation, discrimination, and production of new L2 categories. The amount of perceptual similarity and distance between L1 and L2 categories have been used as explanatory factors both for the perceptual assimilation patterns of L1 and L2 phones (PAM; Best, McRoberts, & Sithole, 1988; Best & Strange, 1992; Best, 1995; PAM-L2; Best & Tyler, 2007; Tyler, 2019) and for the formation of new L2 categories (SLM; Flege 1992; 1995; 2005). In this section, I will be looking at phonemic categories in broader terms, by examining phonemic inventories in general, and how their size, organisation, and categories can impact on L2 learning.

Previous observations on the organisation of vowel inventories in relation to their size have been summarised by the theory of Adaptive Dispersion (Liljencrants & Lindblom, 1972; also see Diehl, Lindblom, & Creeger, 2003; Disner, 1984; Lindblom, 1986; Livijn, 2000), according to which the vowels of languages with small inventories occupy a larger space by having large perceptual distances from one another, as opposed to languages with large inventories for which the vowels tend to cluster together and have smaller distances. Using this theory in relation to the models of L2 speech perception and production discussed in the previous section, I would argue that L2 learners whose native language has more vowels and vowel contrasts than the L2 have an easier task than those whose L1 has a small inventory and they need to learn the categories of a more complex L2. I draw this conclusion from the fact that native speakers of complex systems are already trained in discriminating and producing subtle differences in their L1, therefore, learning a language with either smaller segments or fewer contrasts than their native would be an advantage to those who would experience the opposite.

A number of studies have examined the relationship between L1-L2 inventory sizes and perceptual abilities or production accuracy in the L2. For instance, Boersma and Escudero (2008) examined the identification and categorisation accuracy of learners whose native language has a large vowel inventory (Dutch) and learnt a language with a small inventory (Spanish). The fact that L2 speakers had to learn the vowels of a language with a smaller number of vowels to their native was seen as an advantage, since the Dutch native speakers seemed to use a subset of their already established vowels in order to map phonological representations of the new, Spanish vowel categories: no new category formation or split of an existing one would be necessary for the Spanish L2 learners.

According to Boersma and Escudero (2008), when Dutch native speakers were asked to identify the five Spanish vowels, Dutch native speakers were more accurate, as they are more experienced in perceiving fine acoustic details that do not exist in Spanish. To exemplify, for the /e/ category, there are two variants in Dutch, /ɛ/ and /eː/, but only one in Spanish. The same is observed for the remaining vowel categories. When native Spanish L2 learners of Dutch were asked to categorise Dutch vowels, they chose the vowels with a similar perceived duration to their native language as appropriate tokens. Therefore, when it comes to perception, listeners categorised the tokens of the L2, based on perceived similarity with their native language. Therefore, being a native speaker of a language with a large number of phonemes might present an advantage as the existence of more categories also suggests more experience with perceiving fine acoustic differences as opposed to having experience with less categories and thus less perceptual sensitivity.

In another perceptual study, Kivistö-de Souza and Carlet (2014) examined the identification of English vowels by Catalan and Danish L2 learners. Catalan has a small vowel inventory size, while Danish and English have equally large vowel inventories, even though not all the segments between the two languages share the same characteristics. L2 learners' perceptual sensitivity to tense-lax vowel contrasts (that are only present in English, but not in Danish or Catalan) was tested between a native language with a small inventory (Catalan) and an L2 with a large inventory (English) or between an L1-L2 pair with equally large systems (English-Danish). The Catalan speakers, not being experienced in perceiving fine acoustic cues from their native language did not use spectral cues to identify and discriminate tense and lax L2 English vowels. Instead, they over-relied on duration, as not only it is a contrast which exists in their native language, but it is also a cue that L2 learners are seen to frequently rely on. Danish speakers on the other hand, being experience in cue-weighting, used spectral information to discern the contrast between the English /i/ and /ɪ/.

Cue-weighting in L2 learning and how this is influenced by the languages' phonemic inventories is seen as a key factor in developing perceptual sensitivity in L2 categories. For instance, native speakers of languages with large vowel inventories tend to expand their perceptual space in order to accommodate such a large number of segments and thus perceive longer distances between individual vowels, which is not the case for speakers of languages with a small number of vowels (Hacquard, Walter, & Marantz, 2007). This observation has also been made in production: for instance, Jongman, Fourakis, and Sereno (1989) have shown that speakers of German, which has a large vowel inventory size, expand their acoustic space relative to languages with smaller inventories, such as Greek. Generally, L2 speakers whose L1 benefits from a large sound inventory are claimed to be at an advantage, as languages with large vowel inventories tend to expose their speakers to fine spectral differences (Fox, Flege, & Munro, 1995; Frieda & Nozawa, 2007; Hacquard, Walter, & Marantz, 2007; Iverson & Evans, 2007). This experience though is not shared by speakers of languages with small inventory sizes.

Meunier, Frenck-Mestre, Lelekov-Boissard, and Le Besnerais (2003) on the other hand, studied both the perception and the production of vowels by speakers of small and large inventory size languages, specifically French, English, and Spanish. Meunier et al. (2003) identified three types of vowel spaces that were claimed to represent different sound organisations across the world's languages. One type refers to those vowel spaces in a language that a single vowel might be represented by two vowels in a different language. The other type includes those vowel spaces that are "constant" (Meunier et al., 2003, p. 723), therefore, regardless the density of the articulatory space, the latter is "unexploited" (p. 723). The final type of vowel space to be identified is one that although may be fixed, phonologically similar vowels might differ across two languages. With the previous definitions in mind, Meunier et al. (2003) concluded that the varied vowel inventory size in the three languages (French and English having large ones, and Spanish a small one, with vowels not sharing the same characteristics across languages) does not impact production, as category overlap was observed in the denser systems of French and English, but not in Spanish. However, the vowel space areas across the three languages were constricted to different degrees, even for the small system of Spanish for which the categories would be expected to occupy a larger vowel space area.

To summarise, previous studies examining the link between two phonemic inventories and the role of their size in the acquisition of a second language have been focusing on how experience in a large inventory affects the perceptual sensitivity in phonemic categories of a smaller inventory and vice versa, while the implications of those perceptual effects on production have been largely understudied, to my knowledge. For this reason, I decided to explore how linguistic experience in a small inventory can affect the production of vowel contrasts of a larger phonemic inventory.

I chose the language pair of Standard Modern Greek (SMG) and British English (BE) as an example of a small versus a large inventory. The two systems not only do they differ in terms of size (BE consists of approximately three times more vowels than SMG), but also in terms of vowel features (BE vowels are characterised by the tense versus lax contrast, as opposed to SMG for which the contrast is inexistent). I have already presented a detailed account of the acoustic characteristics of SMG vowels earlier in the thesis (Chapter 2) as well as a description of the BE vowels (Chapter 3), and a comparison of the two systems. In short, SMG comprises 5 vowels: /i/, /ɛ/, /ɐ/, /o/ and /u/. /i/ is a high-front open vowel, /o/ and /u/ are high, back, and rounded (/u/ being higher than /o/). /ɛ/ is a front open-mid vowel with relatively the same degree of height as /o/ at the back. Finally, /ɐ/ is a low central open vowel (for instance see, Jongman, Fourakis, & Sereno 1989; Fourakis, Botinis, & Katsaiti, 1999).

Apart from tongue height and position, elements that are used to characterise both SMG and BE vowels, BE vowels are also described in terms of length (tense/ lax) and roundness (rounded/ unrounded) [1], as described in English phonetics and phonology guides (for instance, see Knight, 2012; Ladefoged, 2001; Roach, 2004; 2009). In the highest and most fronted position of the chart there is /iː/ a tense high front unrounded vowel; its lax counterpart being /ɪ/, which is close and unrounded. /ɛ/ is another front vowel, a lax, open-mid unrounded vowel. Another front vowel, lower than /ɛ/ is the lax, near-open unrounded /æ/. In the centre of the vowel quadrilateral there are two vowels: /ɜː/, which is tense, open-mid, central, and /ʌ/, a lax, open-mid, central unrounded vowel. At the back of the quadrilateral there is /ɑː/, which is tense, open, back, unrounded, /ɒ/, a lax, open, back, rounded vowel, /ɔː/, a tense, open-mid, back, rounded vowel. In the highest and back positions of the quadrilateral there is /uː/, which is tense, close, back, and rounded, and /ʊ/, which is lax, close, back, and rounded. I am providing below the updated IPA vowel chart for reference, with the vowels used in this study noted (Figure **??**).

[1] I am only describing the monophthongs that were used in this study in this section, although more vowels are identified on the chart, as referenced.

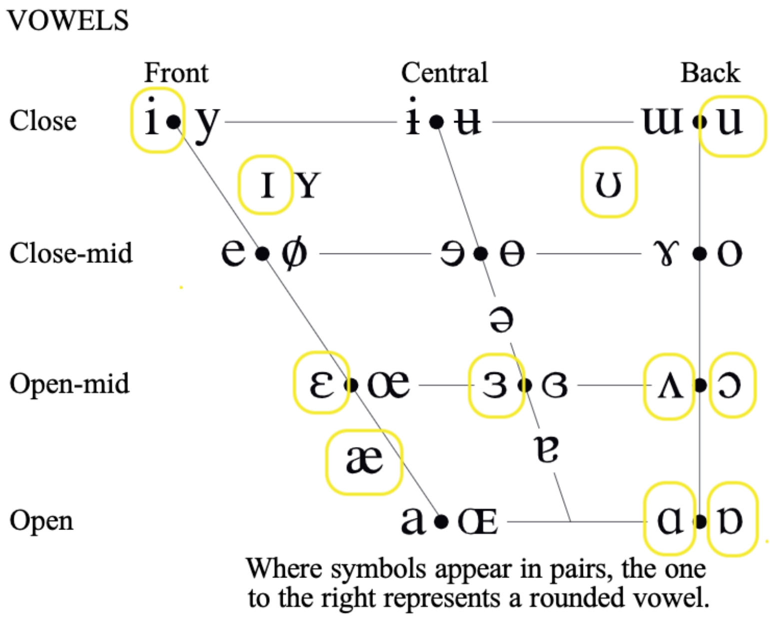


Figure 4.1: Standard Southern British Vowels (International Phonetic Association (IPA), 2015). The vowels noted in yellow are those tested in this study.

Comparing the two systems, it is clear that they vary significantly in terms of size, vowel features, and vowel categories. One of the main differences is the existence of vowel length in BE, which is not observed in SMG. The only case of "longer" vowels is SMG appears when those are found in a word final position, as demonstrated in Chapter 2. In that case, longer vowels are possibly observed as an effect of stress. When it comes to vowel categories, there are only 5 vowels which correspond to 5 categories: one for the high front vowel, one for a front, mid-open vowel, one for a low central vowel, another one for a mid-high back vowel, and a final one for a high back vowel. In BE those categories are represented with more than one vowel.

4.1.3 Research Questions and Hypotheses

So far in this paper, I have discussed that producing phonemic categories and contrasts in an L2 can be largely impacted by the systems of both the L1 and the L2 in a number of ways. One of the main factors impacting L2 production is the ability of L2 learners to form new phonetic categories in their second language, which, in turn, depends on the degree of similarity or dissimilarity between L1 and L2 phonetic categories (for instance, Flege, 1992; 1995; 2005; Flege et al., 2020). The degree of resemblance between categories is also found to impact perceptual assimilation patterns (Best et al., 1988; Best & Strange, 1992; Best, 1995), while the size, organisation, and amount of contrasts between the L1 and L2 phonemic systems can also affect L2 perceptual and production patterns (Boersma & Escudero, 2008; Kivistö-de Souza & Carlet, 2014; Meunier et al., 2003 and others). Experienced L2 learners with a large amount of exposure, frequently at an immersion setting, as well as native speakers of languages with large phonemic inventories seem to be at an advantage when producing L2 phonemic categories.

However, as the overwhelming amount of studies on L2 speech production, to my knowledge, has focused on highly experienced learners who were first exposed to and acquired the L2 by living in a country where the L2 is dominantly spoken as well as on performance on perceptual categorisation and phoneme identification, I am interested in exploring further what happens with L2 learners who were exposed to the L2 at an instructed setting and only received naturalistic input late in life and not for such extended periods as previous studies have acknowledged. Specifically, the research question I aim to address in this chapter is whether experienced L2 learners whose native language both has a small inventory and lacks spectral and temporal contrasts amongst vowels, can produce vowel categories and contrasts which do not exist in their L1.

I will be looking at the L2 learners' productions of BE vowels, by examining the vowels' spectral and temporal characteristics. In terms of forming new categories, I will hypothesise here that the productions of the L2 Learners will differ to those of monolingual controls for the vowels that do not exist in their native language inventory (/ɪ, ʊ, ɔː, æ/), which are expected to be assimilated in single vowel categories (/i, u, o, ɛ/ respectively), sharing acoustic characteristics of both the L1 and L2, following the predictions of PAM-L2 (Best et al., 1988; Best & Strange, 1992; Best, 1995) and SLM (Flege, 1992; 1995; 2005; Flege et al., 2020). Assuming that the L2 Learners might be able to acquire some features of the L2 categories given their experience to the L2 both at an instructed setting in their Home country followed by naturalistic exposure to the L2 following migration to the foreign country, I would expect the learners' productions of L2 categories to incorporate characteristics of both L1 and L2 categories. This might result in "merged" categories with shared L1-L2 characteristics, and might be manifested as phonemes which do not occupy the same positions on the acoustic space as phonemes produced by native speakers of either language would. In terms of vowel duration, I would expect that the L2 learners would produce tense vowels using temporal correlates, in other words, with extended durations, given that speakers of languages for which tense-lax contrasts are absent, demonstrate reliance on temporal cues rather spectral properties, contrary to what would be the case for speakers who are experienced in those from their native language.

The final area I wish to explore in this paper is that of vowel spaces and how the vowel space of L2 learners compares to those of native speakers. Given that the learners in this study have extended experience to a small inventory from their native language, this pattern from their native language might be employed for the space of BE vowels too. I therefore expect that the area occupied by the vowels produced by L2 learners will be smaller compared to that of native BE speakers, whose vowels might occupy a larger total space, given the large number of phonemes, although there might be some overlap between categories, as previously seen in Meunier et al. (2003).

4.2 Methodology

So far, I have shown that a number of factors may have an effect on second language speech. In this paper I am focusing on the effects that the organisation and size of the native language inventory can have on L2 learners' productions of non-native sounds. I am also focusing on the ability of L2 learners to produce phonemic categories and contrasts that do not exist in their native language. The language pair I chose for this study was SMG and BE for the reasons outlined earlier (vowel inventory size, the existence of tense/ lax contrasts, and the difference in vowel categories among the two languages). To investigate the hypotheses formulated, I chose to test a group of native Greek L2 learners of BE in their phonological productions, also testing a group of monolingual native BE speakers for comparison. Participant recruitment was conducted via a flyer advertising the study, which was posted on social media and was forwarded through mailing lists to students and staff members at the University of Essex. Alternatively, some of the participants advertised the study to their contacts via word of mouth. Below are the descriptions of the two groups tested.

4.2.1 Participants

Native Greek L2 Learners of British English

For the test group I recruited the same group of adult participants who took part in the study presented in Chapter 2. To summarise, those were 20 native Greek speakers having English as their second language, aged between 21 and 40 years (mean age: 27.2 years, SD: 5.2; 10 females), however, as one female participant did not produce a sufficient number of responses for acoustical analysis, only the responses of the remaining 19 participants (aged 27.2 years, SD: 5.1) were included in the final analysis. Drawing from the self-assessed responses the participants gave after completing a language background questionnaires (please refer to Section 2.2.3 for further details on the questionnaire used), the majority of participants originated from mainland Greece: 12 from Athens, 6 from Thessaloniki, and 1 from Crete. All reported to be speaking the Standard Greek variety. Apart from Greek, they also reported to be highly proficient in English to which they were exposed after age 5 and learnt at an instructed setting from native Greek qualified teachers of English as a second language. Specifically, participants reported to have been exposed to English for at least 7 years (between 7 and 15 years, M = 10.3 years, SD = 2.2) between the ages of 5 and 9 (M = 7.1, SD = 1.3) at an instructed setting in Greece and they rated themselves as highly proficient by reporting to be at level of competence C1 or C2 in terms of the Common European Framework of Reference for languages (CEFR; Council of Europe, 2001). However, they also all noted that they were not frequent users of their L2 while in Greece, as English was rarely used outside the classroom setting, and the daily L2 usage was reduced even more after the learners stopped taking English classes.

The chosen participants then emigrated to the UK between the ages of 17 and 27 (M = 21.5, SD = 2.2) for studies or employment at the University of Essex and at the time of testing they had already resided in the UK continuously between 3 and 17 years (M = 4.7 years, SD = 3.3), so they were only exposed to the Standard Southern variety. Since their arrival to the UK, the participants became daily users of English in all modes of communication (speaking, understanding spoken and written English, and writing), and estimated to have been using English between 40 and 90% of their day (M = 63.6 %, SD = 16.9). They also reported being confident in the use of their L2, even more so in the receptive skills (reading and understanding spoken utterances). They also estimated to be using SMG for the remainder of the day (between 10 and 60%, M = 36%, SD = 16.9), mainly in speaking, when interacting with family and friends or when listening to or reading Greek media.

Another point that the participants reported on was that of knowledge and usage of other languages apart from their native and L2. 15 of the respondents claimed to have been exposed to an additional foreign language (6 were exposed to French, another 6 to German, 1 to Russian, 1 to Spanish, and 1 to Mandarin Chinese) after being exposed to their L2 (between the ages of 8 and 31 years; M = 13.1, SD = 5.5), at an instructed setting. All exposure to that additional language was in

Greece; the participants had not used that language outside the foreign language classroom, and were not using the language at all at the time of testing, nor they reported being confident to it when tested, so I would conclude that knowledge of an L3 would not interfere with the vowel productions in this study. The detailed profiles of the chosen participant group can be seen in Tables **??** and **??** for L1 and L2 and in the Appendix for L3 (**??**).

Participant No	Gender	Age	Place & Country of Birth	Years in Greece	Years in the UK	Years of English exposure in Greece	Years of English exposure in UK	L1	Percentage of daily usage of L1
11	F	24	Athens, Greece	21	3	10	3	Greek	20%
21	M	23	Heraklion, Greece	20	3	8	3	Greek	30%
22	F	24	Athens, Greece	20	4	9	4	Greek	60%
23	F	28	Athens, Greece	23	5	13	5	Greek	40%
24	M	21	Athens, Greece	17	4	12	4	Greek	55%
25	M	28	Athens, Greece	25	3	11	3	Greek	30%
27	M	24	Athens, Greece	20	4	8	4	Greek	60%
27	M	22	Athens, Greece	19	3	10	3	Greek	40%
29	F	28	Athens, Greece	21	7	11	7	Greek	20%
32	M	29	Athens, Greece	23	3	10	3	Greek	10%
35	F	40	Athens, Greece	22	17	10	17	Greek	15%
36	F	25	Thessaloniki, Greece	22	3	10	3	Greek	20%
38	F	38	Thessaloniki, Greece	22	3	10	3	Greek	60%
49	M	28	Thessaloniki, Greece	24	3	8	3	Greek	30%
50	F	24	Thessaloniki, Greece	20	4	7	4	Greek	30%

Participant No	Gender	Age	Place & Country of Birth	Years in Greece	Years in the UK	Years of English exposure in Greece	Years of English exposure in UK	L1	Percentage of daily usage of L1
51	M	36	Thessaloniki, Greece	27	9	15	9	Greek	20%
53	F	25	Athens, Greece	20	5	11	5	Greek	50%
54	M	27	Thessaloniki, Greece	23	4	8	4	Greek	40%
55	M	24	Athens, Greece	21	3	15	4	Greek	60%

Table 4.1: *L1 background information of Greek adults*

Participant No	L2	L2 Age of first exposure	L2 Age of first exposure to Listening	L2 Age of first exposure to Reading	L2 Age of first exposure to Speaking	L2 Age of first exposure to Writing	Percentage of daily usage of L2
11	English	7	7	7	7	7	80%
21	English	8	8	8	8	8	70%
22	English	7	7	7	7	7	40%
23	English	7	7	7	7	7	60%
24	English	5	5	5	5	5	45%
25	English	5	5	5	5	5	70%

Participant No	L2	L2 Age of first exposure	L2 Age of first exposure to Listening	L2 Age of first exposure to Reading	L2 Age of first exposure to Speaking	L2 Age of first exposure to Writing	Percentage of daily usage of L2
27	English	7	7	7	7	7	40%
27	English	7	7	7	7	7	60%
29	English	6	6	6	6	6	80%
32	English	8	8	8	8	8	90%
35	English	9	9	9	9	9	85%
36	English	8	8	8	8	8	80%
38	English	8	8	8	8	8	40%
49	English	8	8	8	8	8	70%
50	English	7	7	7	7	7	70%
51	English	5	5	5	5	5	80%
53	English	9	9	9	9	9	50%
54	English	8	8	8	8	8	60%
55	English	6	6	6	6	6	40%

Table 4.2: *L2 background information of Greek adults*

British English Monolingual Adults

The control group for this study consisted of 20 adults (aged 30 years, SD: 12.1, from 18 to 55 years; 16 females). At the time of testing, all participants were residing in the South East of England and had lived there for several years before taking part in the study. Before moving to Essex, they all reported to have been born and or have lived in surrounding areas to Essex. Like the L2 group, the controls were also students or employees at the University of Essex. In terms of languages, 15 of the participants were monolinguals: they had no knowledge or exposure to any other languages apart from English. The rest reported being taught a second language at school (French or German), but to a beginners level and not beyond basic conversational phrases. They had not used their L2 since leaving school and had lost all confidence in using it in any mode of communication. Finally, all participants were using British English daily as the sole means of communication, either spoken or written, and at the time of testing they were receiving no other foreign language input.

4.2.2 Tasks

The purpose of this study was to test L2 learners' phonological productions of BE English vowels and vowel contrasts. For the purposes of consistency, I chose to use the same elicitation tasks as those used in the children's study (Chapter 3), whilst I only adapted the wording of the instructions in order to appeal to the adult audience. For the duration of the experimental procedure, all participants were both addressed to and were responding in English. What I am presenting in this section is a summary of the tasks and instructions used for the adult groups, as the tasks were presented in more detail in the previous chapter.

Task 1: Story book

The first elicitation task was in the form of a story book ("The animals are going on a picnic"). The entire story was presented in writing, apart from 30 words, the ones containing the test items, which were replaced by pictures. The entire story was read by the experimenter, apart from the test items to which the participants were asked to respond, by naming them, while their responses were audio recorded. Details of the test items, study setup, and recording conditions can be found in the next section. It is worth mentioning here that the vowels examined were placed in consonant frames, and were presented twice in a different consonantal environment each time, in a random order so that neither the same vowel nor consonant frame appeared consecutively.

However, the order of presentation could not be fully randomised, as it was restricted by the fact that the words had to be presented in a meaningful context, that of plausible and coherent sentences. Therefore, apart from ensuring that not the same vowel or consonantal environment would appear in consecutive items, no other randomisation procedure was followed. This task was presented to the participants first, who were told that the story would be read to them by myself, the experimenter, apart from the picture items which they would need to name. I am providing a sample page from the story book under Figure **??**, for reference.

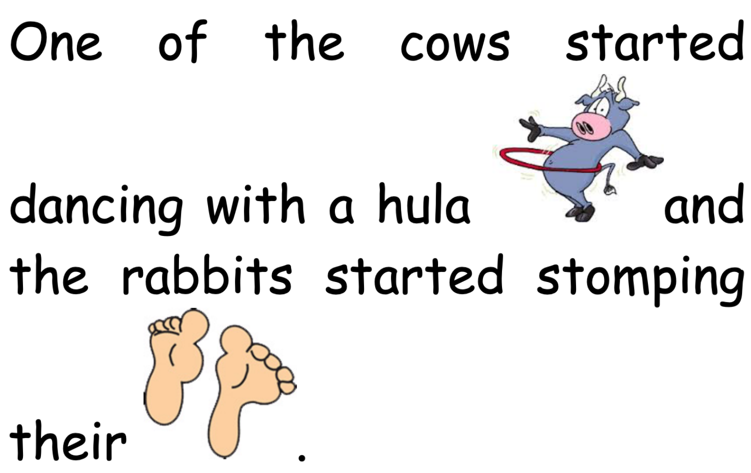


Figure 4.2: Story book sample page with two words elicited

Task 2: Matching task

The second elicitation task was a confederate description task, related again with naming various picture stimuli (N=45). This set of stimuli included the subset of 30 items presented in the story book and an additional repetition of each vowel token. The stimuli shown this time were individual pictures, each in the middle of a PowerPoint slide, which was displayed on the screen for 4 seconds. The participants once again were asked to name the pictures as soon as they appeared on the screen. The experimenter was holding a folder with the same pictures in the form of picture cards and was ordering the cards in the presentation order as soon as those were named by the participants. The stimuli were presented in a random order, to avoid frequency effects from displaying the story book subset in the same order as in the previous task or from displaying the same vowel in consecutive items (Jeschniak & Levelt, 1994).

Task 3: New story

The final task required the participants to use the (now "ordered") picture cards in context, by developing a story of their own. I used the same items as in the previous task, although this time the pictures were not named individually, as previously, but in context. Although the adults were limited in terms of the order they could use the stimuli in their stories, they were still encouraged to use their imagination to create a story on any topic. The stories created were not prompted in any way by the experimenter: the adults developed their story unaided in this free production task.

4.2.3 Materials and Stimuli

Language background questionnaires

Before participating in the tasks outlined earlier, the participants were asked to complete a language background and experience questionnaire, to gain an understanding of their language background, confidence levels in productive and receptive skills across their languages, and languages spoken by each participant. The questionnaire used was adapted from the Language History Questionnaire (LHQ; Li, Sepanski, & Zhao, 2006; Li, Zhang, Tsai, & Puls, 2014) and the Language Experience and Proficiency Questionnaire (LEAP-Q; Marian, Blumenfeld, & Kaushanskaya, 2007). Below, I am providing a short overview of the questionnaire used and how the adapted version differed from the LHQ and the LEAP-Q.

The first part of the questionnaire focused on collecting biographical information about the participants, so it included questions about their gender, age, level of education, and socio-economic status. The second, and most extended part included questions related to the language background of the participants: how many and which languages they spoke, along with the amount of exposure to and usage of each language, confidence of using their languages in both receptive (reading and listening comprehension) and productive (writing, oral communication) skills, extended stays in foreign countries, length of residence in the UK and so on. There were also questions about who the participants spoke each of their languages with and the order to which they were exposed to each language if there were more than two. They were also asked to self-assess the the amount of foreign accent they felt they were displaying as well as which of their languages they preferred using and at which setting.

The LEAP-Q (Marian et al., 2007) is a detailed questionnaire primarily assessing the linguistic abilities of bilingual adults. It is a battery that at the first stage includes demographic information (name, gender, age) and then focuses on questions related to the participants' languages in order of dominance and order of acquisition, percentages of daily exposure in each of the languages, amount of preference of language use in oral communication and reading. Also, there are questions about the cultures the participants identify with, number of years in formal education, as well as length of stay in the US, and details for any physical, cognitive, or learning deficits. Finally, there are specific questions in the amount of exposure to different linguistic environments, level of proficiency in reading, listening comprehension, and spoken production, different factors contributing to the learning of a second language as well as the degree of foreign accent as identified by the learners themselves and others.

The LHQ (Li et al., 2006; 2014), is an online battery, where participants are initially required to respond to questions on their personal information and demographics (age, gender, contact information, countries of residence and origin), followed by questions on the language habits of the responders in terms of interactions with family and everyday use, age of first exposure to the second language, self-assessed measures of fluency in the receptive and productive language skills, type of second language education received, self-evaluated accented speech, code-mixing, and extended stays in foreign countries.

The two standardised questionnaires provided the basis for the adapted version given to the participants of this study: some of the questions were omitted, for instance, those addressing cultural identification, as all participants came from the same cultural backgrounds, or adapted, like those related to "residence in the US" as the participants were tested in the UK context. I maintained the questions eliciting biographical information as well as language use, amount of exposure to each language, number of languages spoken, and confidence levels in each, as those would provide information around the language background of each participant and determine language dominance and amount of exposure/ usage, variables that might have affected the respondents' vowel productions. The detailed set of questions used can be viewed in Appendices 1-3.

Test Items

In this study, I focused on the phonological productions of BE vowel categories and contrasts that do not exist in the L2 learners' native language. For this reason, I chose 11 monophthongs of BE which are part of a tense-lax pair (/iː/-/ɪ/, /uː/-/ʊ/, /ɜː/-/ɛ/), the central vowels /ʌ/, /ɒ/, /ɑː/, for which there is only one equivalent in SMG (/ɐ/), as well as /ɔː/ and /æ/. It is worth noting here that in the tasks described in the previous section, I mentioned that there were 30 (Story book task) and 45 (Matching task and new story task) stimuli; this is because in both tasks some stimuli contained the diphthongs /aɪ/, /eɪ/, /aʊ/, /oʊ/, which were used as fillers, so although elicited, they were not analysed.

As the tasks were the same as in the children's study described in Chapter 3, so were the tests items and the procedure for selecting them. To sum up, the monophthongs tested were placed in consonant frames, for instance, /ʃVt/, /hVt/, /bVd/, to make, in their vast majority, monosyllabic words (except for "kettle", "honey", "pencil", and "hippo"). As it was necessary for the stimuli to make up real words that would represent concrete nouns easily depicted and recognisable by the child participants of the previous study (described in Chapter 3), it was not possible to maintain the same consonant frame for all the test items. Some criteria had to be met though in the selection of the vocalic environment in order to avoid interference in the vowel productions. For instance, nasals (with the exception of the frames /hVn/ in "honey" and "horn" and /mVn/ in "moon"), liquids, and glides were avoided in order to eliminate assimilation effects. I maintained the /hVn/ and /mVn/ vocalic environments for the 4 items mentioned earlier for two reasons: first, as the stimuli needed to be concrete, depictable, and high frequency words to be easily elicited, this restricted the amount of usable words. Secondly, the nasal followed the vowel in all cases, which could be isolated during the annotation process, so I decided that the two would be usable frames. I mostly opted for voiced and voiceless stops (/p/, /t/, /k/, /b/, /d/, /g/) though, coronal fricatives (/s/ and /ʃ/), and labiodental and voiceless fricatives (/f/ and /h/ respectively), as neutral, in order to minimise any interference.

The test items were controlled in three ways: first, the frames were recurring across items. For example, the frame /kVt/ was used for the following vowels: /ɛ/ in "kettle", /æ/ in "cat", /ɑː/ in "cart", and /ʌ/ in "cut". Second, the test vowels appeared in a stressed position across stimuli, in order to eliminate any effects of environment, position or stress on the production of the vowels. Finally, the the number of occurrences of each vowel in the tasks was controlled for: there were two repetitions of the same vowel in the first task and three for the second and third task. Below, there is a detailed account of the consonant frames and vowels used per task. Table **??** shows the stimuli elicited in the story book task and **??**, those elicited in the matching and new story tasks [2]

[2] The IPA transcriptions used in the presentation of the test items are those suggested by the updated IPA charts (International Phonetic Association (IPA), 2015). For this reason, for instance, the symbol /ʌ/ is used for a low central vowel in the words "shop, cut", and "honey" instead of /ʌ/ that might appear in older versions (Roach, 2004).

Table 4.3: *Consonant Frame Frequencies and Words per Vowel Token in Task 1*

Target Vowel	Frequency	Consonant frame	Words
æ	2	k_t	cat
		h_t	hat
ʌ	2	k_t	cut
		h_n	honey
ɑː	2	k_t	cart
		h_t	heart
ɒ	2	h_t	hot
		ʃ_p	shop
ɜː	2	b_d	bird
		ʃ_t	shirt
iː	2	ʃ_p	sheep
		f_t	feet
ɪ	2	ʃ_p	ship
		h_p	hippo
ɔː	2	h_n	horn
		h_s	horse
uː	2	h_p	hoop
		b_t	boot
ʊ	2	f_t	foot
		h_d	hood
ɛ	2	k_t	kettle
		b_d	bed

Table 4.4: *Consonant Frame Frequencies and Words per Vowel Token in Tasks 2 and 3*

Target Vowel	Frequency	Consonant frame	Words
æ	3	k_t	cat
		h_t	hat
		b_g	bag
ʌ	3	k_t	cut
		h_n	honey
		m_n	monkey
		s_n	sun
ɑː	2	k_t	cart
		h_t	heart
ɒ	3	h_t	hot
		ʃ_p	shop
		d_g	dog
ɜː	3	b_d	bird
		ʃ_t	shirt
		g_l	girl
iː	3	ʃ_p	sheep
		f_t	feet
		p_s	peas
ɪ	3	ʃ_p	ship
		h_p	hippo
		p_g	pig
ɔː	3	h_n	horn
		h_s	horse
		s_d	sword
uː	3	h_p	hoop
		b_t	boot
		m_n	moon
ʊ	3	f_t	foot
		h_d	hood
		b_k	book
ɛ	3	k_t	kettle
		b_d	bed
		p_n	pencil

Equipment and Acoustic Measures

The recording conditions, equipment, vowel identification and labelling were the same as in the previous papers, described in Chapters 2 and 3. With regards to equipment, I used a Sennheiser MD42 omnidirectional microphone, mounted on a table base, and placed sideways to the participants' mouths at approximately a 10cm distance. The microphone was connected to a Behringer Xenyx 502 Analogue Mixer preamp with a 3-pin XLR cable, and to a MacBook Pro laptop with Praat installed (Boersma & Weenink, 2006). Praat was used for the recordings, which were conducted in mono at a 44.1 kHz sampling rate in a quiet room in the Department of Language and Linguistics, University of Essex, which permitted to maintain the same procedure and recording conditions for all participants. After obtaining the recordings, the test items were isolated and manually extracted in Praat before being annotated using Praat's TextGrid function. Visual inspection of the spectrograms and waveforms was also used to confirm the vowel boundaries.

In terms of acoustic measures, the following were obtained and analysed: first, the values for vowel duration were calculated and analysed in order not only to determine whether vowel duration which is not contrastive in SMG as illustrated in Chapter 1, can be acquired and produced in SSBE vowel categories. The next variables to be analysed were the normalised values of the first two formants F_1 and F_2. The reason for obtaining and analysing the values of the first two formants was twofold: first, they were used to determine the vowels' height (F_1) and backness (F_2), therefore, the vowels' position on the acoustic vowel space. Positioning the vowels on the vowel space also helped calculate the total vowel space area, which would help in the comparison between the acoustic vowel space of L2 learners and native English speakers.

4.3 Results

The normalised F_1 and F_2 values as well as vowel Duration were statistically analysed by means of linear mixed modelling to account for different sources of variability, for instance, unequal number of tokens obtained per vowel. The linear mixed models were computed in R (R Core Team, 2018), using the *lmer* (De Boeck et al., 2011) and *lmerTest* (Kuznetsova et al., 2015) packages. Candidate models were chosen by adding factors of interest to the model and assessing whether they improved the model fit. Before this, each acoustic measure was tested for normality and was Log transformed if necessary. F_1 and F_2 were already normally distributed as the raw values had been previously normalised, so Log transformation was not necessary for the formant values. Duration was log transformed though, to correct for normality. The last measure that was analysed was vowel space area, which was calculated automatically in phonR (McCloy, 2016).

4.3.1 Duration

Mixed effects models for duration were developed by adding those fixed effects factors that contributed significantly to the model fit. For the model including both participant groups, those were *target vowel* (11 levels: /ɐ/, /ɒ/, /ɑː/, /æ/, /ɛ/, /ɜː/, /ɪ/, /iː/, /ʊ/, /uː/, /ɔː/), *participant group* (2 levels: adult L2 Learners and Monolingual controls), and *task type* (2 levels: words produced in context and words produced in isolation). *Participants* and *test items* were the random effects in the models. Further models were developed by adding the factors that were relevant to the L2 learners only. Those were *Age, Age of Onset of English, Years of Residence in the UK, Length of Exposure to English* both in Greece and in the UK, and *Percentage* of English and Greek usage per day.

All participant groups

The presentation of results will begin with the duration plots for both participant groups (L2 Learners and Monolingual controls). Looking at Figure **??** and Table **??**, L2 Learners overall produced longer lax vowels as opposed to Monolingual controls who produced longer tense vowels.

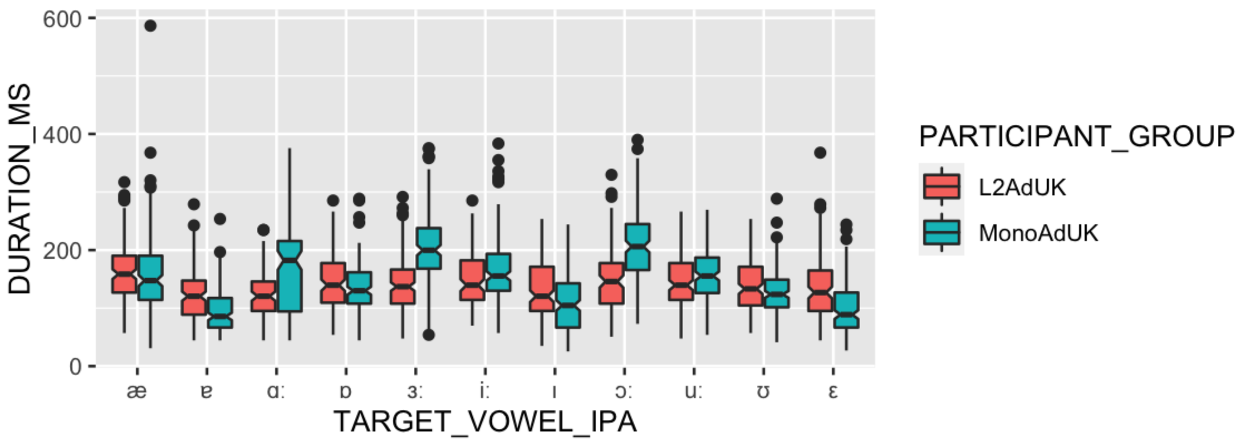


Figure 4.3: Average duration (ms) for vowel categories per participant group. *"L2AdUK" stands for L2 (Adult) Learners in the UK, and "MonoAdUK" stands for Monolingual Adults in the UK. "TARGET_VOWEL_IPA" stands for the target vowels examined in this study, in IPA transcription.*

Table **??** shows the average duration (in ms) per vowel category for the two participant groups.

Table 4.5: *Average duration (raw values in ms) and standard deviation (SD) for vowel categories per participant group.*

Target Vowel	L2 Learners (SD)	Monolinguals (SD)
æ	169.62 (48.9)	156.45 (57.1)
ʌ	122.87 (43.1)	92.00 (33.29)
ɑː	129.65 (41.90)	166.20 (77.53)
ɒ	146.73 (44.81)	135.53 (39.71)
ɜː	142.50 (49.28)	204.69 (56.76)
iː	146.88 (47.74)	171.24 (65.60)
ɪ	121.48 (50.43)	105.27 (45.66)
ɔː	166.54 (50.33)	216.61 (71.58)
uː	145.58 (44.84)	160.67 (44.21)
ʊ	138.77 (43.18)	124.23 (37.88)
ɛ	127.96 (52.68)	97.90 (41.69)

Following descriptive statistics and plotting of the vowels, the first linear mixed effects model was developed for Duration, for which *Target Vowel, Participant Group*, and *Task Type* were the fixed effects and *Participants* and *Response* were the random effects. As per Table **??**, the factors Target Vowel and Task Type significantly improved the model fit ($p < .001$ and $p = .001$ respectively), but Participant Group did not ($p = .69$).

Table 4.6: *The fixed effects (Target vowel, Participant groups, and Task type) and the Target vowel*Participant group interaction in the linear mixed model for Duration. The baseline for Target vowel is /ʌ/, for Participant group is Monolingual Adults (in the) UK, and for Task type is (words produced in) Isolation.("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	LogDuration	
Target Vowel æ	0.438***	(0.146)
Target Vowel ɑː	0.169	(0.153)
Target Vowel ɒ	0.330**	(0.156)
Target Vowel ɜː	0.339**	(0.139)
Target Vowel iː	0.411***	(0.152)
Target Vowel ɪ	0.018	(0.136)
Target Vowel ɔː	0.554***	(0.145)
Target Vowel uː	0.325**	(0.145)
Target Vowel ʊ	0.133	(0.140)
Target Vowel ɛ	0.002	(0.148)
Participant Group L2 Adults UK	0.014	(0.043)
Task Type Context	−0.040***	(0.012)
Intercept	−0.410***	(0.123)
Observations	3,163	
Log Likelihood	−989.781	
Akaike Inf. Crit.	2,011.56	
Target Vowel æ : Participant Group L2 Adults UK	−0.269***	(0.049)
Target Vowel ɑː : Participant Group L2 Adults UK	−0.433***	(0.053)
Target Vowel ɒ : Participant Group L2 Adults UK	−0.211***	(0.050)
Target Vowel ɜː : Participant Group L2 Adults UK	−0.684***	(0.049)
Target Vowel iː : Participant Group L2 Adults UK	−0.367***	(0.051)
Target Vowel ɪ : Participant Group L2 Adults UK	−0.068	(0.048)
Target Vowel ɔː : Participant Group L2 Adults UK	−0.623***	(0.051)
Target Vowel uː : Participant Group L2 Adults UK	−0.399***	(0.050)
Target Vowel ʊ : Participant Group L2 Adults UK	−0.123**	(0.049)
Target Vowel ɛ : Participant Group L2 Adults UK	−0.004	(0.050)
Intercept	−0.398***	(0.106)
Observations	3,163	
Log Likelihood	−806.841	
Akaike Inf. Crit.	1,665.683	

In addition to the main effects, I also examined the Target Vowel*Participant group interaction, which was significant ($p < .001$), as per Figure **??** and Table **??**.

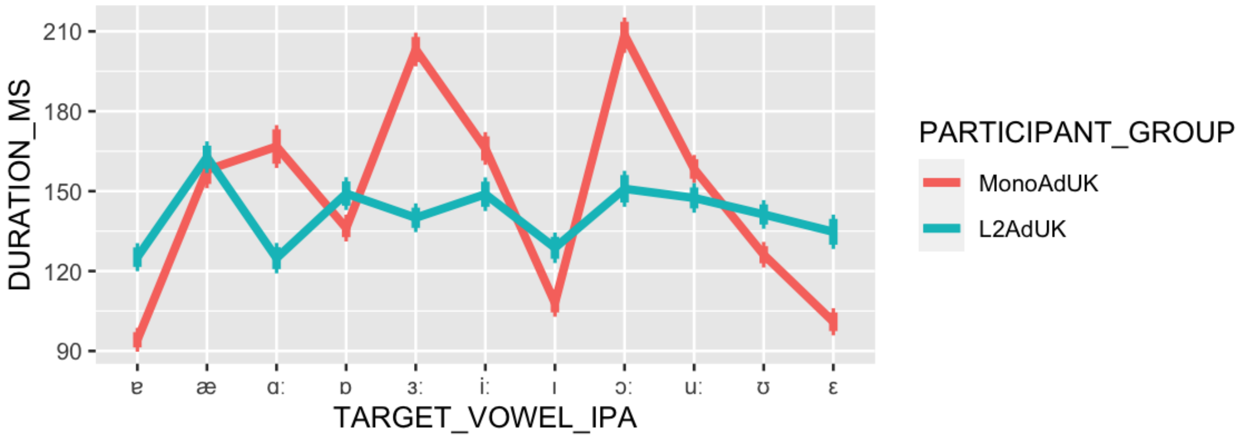


Figure 4.4: *The Target Vowel* Participant Group interaction for the mixed effects model for Duration. "L2AdUK" stands for L2 (Adult) Learners in the UK, and "MonoAdUK" stands for Monolingual Adults in the UK. "TARGET_VOWEL_IPA" stands for the target vowels examined in this study, in IPA transcription.*

L2 Learners

Following developing models for duration including factors relevant for all participants, follow-up models were developed for factors applicable to L2 Learners only. Those were *Age, Age of onset of the L2 (English), Years of English exposure in the UK* (which coincided with the length of residence in the UK), as well as *Years of English exposure in Greece*, and *Percentage of English and Greek usage per day*. Each factor was added separately and was tested as to whether it improved the model fit. The first model included *Target vowel, Participant group, Task Type*, and *Age* as the fixed effects. *Participants* and *Response* were added as random effects, as per Table **??**.

Age did not improve the model fit significantly ($p = .60$), neither as a fixed effect nor as an interaction factor ($p = .22$), and therefore, it was dropped from subsequent models. The next factor that was added to the model was *Age of onset of L2* (labelled as L2_Age), which did not contribute significantly to the model fit ($p = .44$), as seen in Table **??**. Exposure to English in the UK or combined years of exposure to English, in Greece and the UK did not contribute significantly to the model fit either (p = .95 and p = .30 respectively), however, what contributed significantly were the years of English exposure in Greece (p = .001), as well as both the amount of daily English usage (p= .01) and usage of Greek (p= .01), as per Table **??**.

Table 4.7: *The fixed effects (Target vowel, Participant groups, Task type, Age, L2 Age, Years of English exposure to Greece, the UK, combined exposure to English, and daily Percentage of English and Greek usage, as well as the Group*Age interaction) in the linear mixed model for Duration. The baseline for Target vowel is /ʌ/, for Participant group is Monolingual Adults (in the) UK, and for Task type is (words produced in) Isolation. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	LogDuration	
Target Vowel æ	0.437***	(0.145)
Target Vowel ɑː	0.167	(0.151)
Target Vowel ɒ	0.329**	(0.154)
Target Vowel ɜː	0.342**	(0.138)
Target Vowel iː	0.405***	(0.151)
Target Vowel ɪ	0.021	(0.135)
Target Vowel ɔː	0.557***	(0.144)
Target Vowel uː	0.325**	(0.143)
Target Vowel ʊ	0.132	(0.139)
Target Vowel ɛ	−0.055	(0.147)
Participant Group L2 Adults UK	0.017	(0.044)
Age	0.012	(0.023)
Participant Group L2 Adults UK : Age	0.077	(0.064)
Age of Onset to English	− 0.003	(0.044)
Years of English exposure in the UK	0.0001	(0.003)
Years of English exposure in Greece	−0.017***	(0.005)
Total English exposure (UK and Greece)	−0.002	(0.002)
L1 Percentage	−0.004**	(0.002)
L2 Percentage	0.004**	(0.002)
Task Type Context	−0.034***	(0.011)
Intercept	−0.378***	(0.123)
Observations	3,163	
Log Likelihood	−992.300	
Akaike Inf. Crit.	2,122	

4.3.2 Formant Frequencies

After duration was analysed, analysis of the first two formants was also conducted. Following descriptive statistics (Tables **??** and **??**) for each formant, separate linear mixed models were developed for F_1 and F_2. Figures **??** and **??** show the normalised values per formant per participant group in the vowel categories examined in the study.

F_1

All participants

Descriptive statistics suggest a marginal difference in the F_1 values of monolinguals and L2 Learners, with monolinguals producing vowels with higher F_1 frequencies, suggesting lower values. However, when the linear mixed model was used for analysis, the observation was not confirmed statistically as the model output suggests (Table **??**).

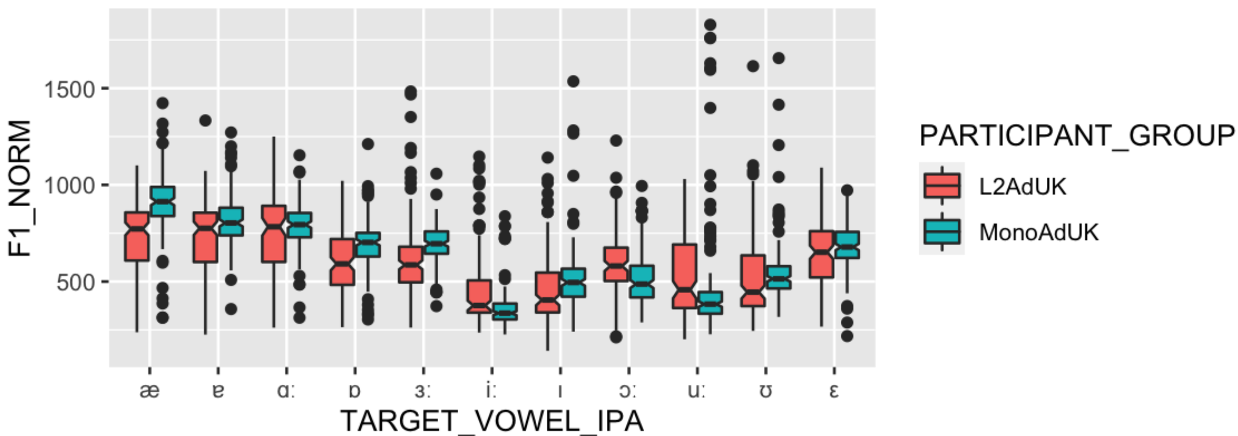


Figure 4.5: Normalised F_1 values (Hz) (F_1_NORM) for vowel categories per participant group. *“L2AdUK” stands for L2 (Adult) Learners in the UK, and “MonoAdUK” stands for Monolingual Adults in the UK. “TARGET_VOWEL_IPA” stands for the target vowels examined in this study, in IPA transcription.*

Table 4.8: *Normalised F_1 values (Hz) and standard deviation (SD) for vowel categories per participant group.*

Target Vowel	L2 Learners (SD)	Monolinguals (SD)
æ	722.71 (62.49)	902.90 (158.66)
ʌ	723.70 (62.49)	817.12 (124.22)
ɑː	738.70 (63.30)	794.18 (117.36)
ɒ	623.05 (45.95)	697.75 (129.28)
ɜː	599.77 (56.83)	695.21 (103.56)
iː	462.07 (59.02)	376.55 (112.84)
ɪ	471.39 (54.34)	519.77 (167)
ɔː	590.29 (49.41)	516.80 (128.29)
uː	534.37 (65.92)	472.47 (272.81)
ʊ	534.40 (173.77)	548.68 (147.24)
ɛ	664.53 (113.20)	691.27 (110.80)

After descriptive statistics, a linear mixed model for F_1 was developed for all participants, as with Duration, using *Target vowel* and *Participant group*, and *Task type* the fixed effects and *Participant* and *Response* as the random effects. For F_1, Target vowel contributed significantly to the model fit ($p < .001$) and all vowels apart from /æ/ ($p = .22$) and /ɑː/ ($p = .44$) also differed significantly from the baseline /ʌ/ in terms of height, whilst what was also significant was the *Target Vowel*Participant group* interaction ($p < .001$) for vowels /æ/ ($p = .02$), /ɪ/ ($p < .01$), /ɔː/ ($p = .03$), /uː/ ($p < .01$), /ʊ/ ($p < .01$), and /ɛ/ ($p = .04$) as per Table **??**. Participant group also contributed significantly to the model fit ($p = .06$), but task type did not ($p = .40$), as it can be viewed in Table **??**.

Table 4.9: *The fixed effects (Target vowel, Participant groups, and Task type) in the linear mixed model for F_1 (Hz), and the Target Vowel*Participant group interaction. The baseline for Target vowel is /ʌ/, for Participant group is Monolingual Adults (in the) UK, and for Task type is (words produced in) Isolation. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	F_1 (normalised) (Hz)	
Target Vowel æ	76.071**	(32.126)
Target Vowel ɑː	−42.168	(32.621)
Target Vowel ɒ	−143.216 ***	(32.745)
Target Vowel ɜː	−130.484 ***	(31.366)
Target Vowel iː	−458.652 ***	(32.543)
Target Vowel ɪ	−319.954 ***	(30.478)
Target Vowel ɔː	−304.897 ***	(31.823)
Target Vowel uː	−344.404 ***	(30.896)
Target Vowel ʊ	−278.971 ***	(30.962)
Target Vowel ɛ	−149.067 ***	(32.037)
Participant Group L2 Adults UK	−98.477***	(26.523)
Task Type Context	−4.928	(6.323)
Intercept	823.217***	(26.038)
Observations	3,163	
Log Likelihood	−20,672	
Akaike Inf. Crit.	41,396	
Target Vowel æ : Participant Group L2 Adults UK	−84.279***	(27.800)
Target Vowel ɑː : Participant Group L2 Adults UK	37.282	(29.890)
Target Vowel ɒ : Participant Group L2 Adults UK	25.455	(28.595)
Target Vowel ɜː : Participant Group L2 Adults UK	11.500	(27.590)
Target Vowel iː : Participant Group L2 Adults UK	196.700***	(29.000)
Target Vowel ɪ : Participant Group L2 Adults UK	58.010**	(27.430)
Target Vowel ɔː : Participant Group L2 Adults UK	179.200***	(29.120)
Target Vowel uː : Participant Group L2 Adults UK	158.100***	(28.010)
Target Vowel ʊ : Participant Group L2 Adults UK	79.440***	(27.910)
Target Vowel ɛ : Participant Group L2 Adults UK	72.340**	(28.630)
Intercept	823.200***	(26.040)
Observations	3,163	
Log Likelihood	−20,672	
Akaike Inf. Crit.	41,397.000	

L2 Learners

After the model for all participants, further models were developed for the factors relevant to the L2 Learners (Table **??**), as previously for Duration. *Age* was the first factor to be added to the model, which did not improve the model fit ($p = .85$), followed by *Years of English Exposure in the UK*, which did not significantly improve the model fit either ($p = .48$). Another factor which was added to the model but did not improve the fit was *Years of English Exposure in Greece* ($p = .32$), as was the case with *Age of onset to English* ($p = .92$). The final two factors which were added to the linear mixed model for F_1 were *Percentage of daily L2 (English)* and *L1 (Greek) usage*. English usage did not contribute to the model fit significantly ($p = .65$), nor did Greek daily usage ($p = .69$), suggesting that L2 Learners produced SSBE vowel categories in the same way as monolingual controls and no factors affecting L2 speech production had a significant effect on these speakers' productions.

Table 4.10: *The fixed effects (Target vowel, Participant groups, Task type, Age, L2 Age, Years of English exposure to Greece and the UK, and daily Percentage of English and Greek usage) in the linear mixed model for F_1 (Hz). The baseline for Target vowel is /ʌ/, for Participant group is Monolingual Adults (in the) UK, and for Task type is (words produced in) Isolation. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	F_1 (normalised) (Hz)	
Target Vowel æ	38.170	(31.228)
Target Vowel ɑː	−24.038	(31.660)
Target Vowel ɒ	-131.788^{***}	(31.759)
Target Vowel ɜː	-128.887^{***}	(29.832)
Target Vowel iː	-372.488^{***}	(31.687)
Target Vowel ɪ	-293.470^{***}	(29.313)
Target Vowel ɔː	-222.825^{***}	(30.555)
Target Vowel uː	-275.191^{***}	(29.980)
Target Vowel ʊ	-242.556^{***}	(29.769)
Target Vowel ɛ	-116.822^{***}	(31.212)
Participant Group L2 Adults UK	-35.440^{*}	(19.063)
Age	−1.835	(9.885)
Age of Onset to English	−0.145	(1.577)
Years of English exposure in the UK	−0.781	(1.126)
Years of English exposure in Greece	2.468	(2.510)
L1 Percentage	0.303	(0.780)
L2 Percentage	−0.343	(0.764)
Task Type Context	−5.358	(6.490)
Intercept	794.102^{***}	(25.670)
Observations	3,163	
Log Likelihood	−20,793.560	
Akaike Inf. Crit.	41,621.120	

F_2

All participants

The second formant to be analysed was F_2, associated with vowel backness. Looking at Figure ?? and Table ??, both L2 Learners and Monolingual controls rendered similar F_2 values when producing SSBE vowel categories.

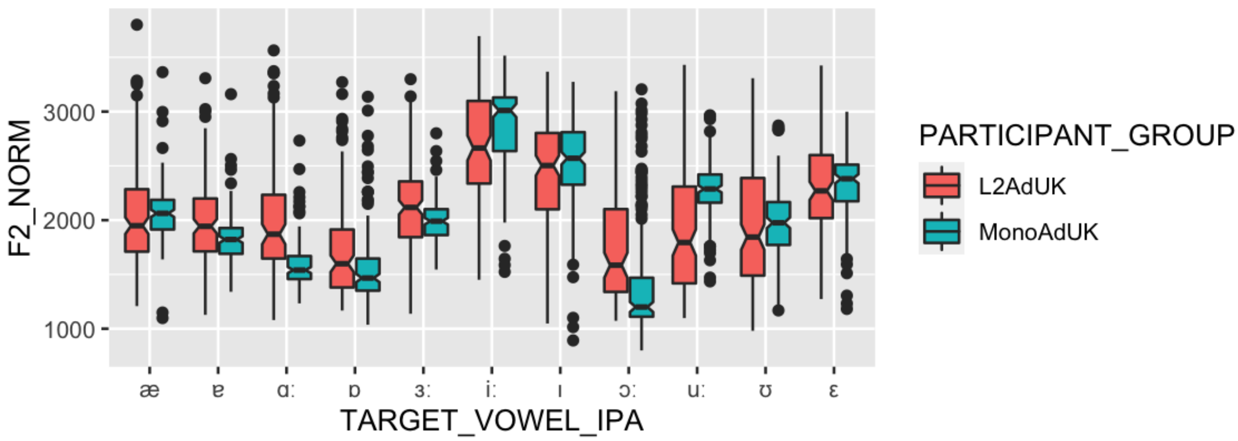


Figure 4.6: Normalised F_2 values (Hz) (F_2_NORM))for vowel categories per participant group.. *"L2AdUK" stands for L2 (Adult) Learners in the UK, and "MonoAdUK" stands for Monolingual Adults in the UK. "TARGET_VOWEL_IPA" stands for the target vowels examined in this study, in IPA transcription.*

Table 4.11: *Normalised F_2 values (Hz) and standard deviation (SD) for vowel categories per participant group.*

Target Vowel	L2 Learners (SD)	Monolinguals (SD)
æ	2051.58 (266.85)	2052.01 (262.50)
ʌ	1985.90 (179.80)	1824.26 (231.92)
ɑː	1996.75 (247.43)	1589.68 (227.65)
ɒ	1731.47 (260.27)	1565.90 (162.44)
ɜː	2109.69 (222.93)	1984.21 (207.83)
iː	2627.67 (362.29)	2876.33 (200.18)
ɪ	2444.63 (241.66)	2876.33 (200.18)
ɔː	1794.33 (380.13)	1446.54 (356.21)
uː	1904.79 (270.65)	2287.49 (263.63)
ʊ	1942.58 (374.58)	1969.06 (108.31)
ɛ	2288.88 (210.85)	2317.35 (133.51)

To confirm the previous observation statistically, a linear mixed model for F_2 was developed, including *Target Vowel, Participant group*, and *Task Type* as the fixed effects, whilst *Participant* and *Response* were the random effects. Factor Target vowel ($p < .001$) contributed significantly to the model fit, whilst participant group ($p = .31$) and and Task type ($p = .99$) did not . Looking at individual vowels, all but /æ/ ($p = .09$), /ɑː/ ($p = .16$), and /ʊ/ ($p = .59$) differed significantly from the baseline /ʌ/ in terms of backness and there was significant interaction between target vowel and participant group ($p = < .001$) as per Table **??**.

Table 4.12: *The fixed effects (Target vowel, Participant groups, and Task type) in the linear mixed model for F_2 (Hz). The baseline for Target vowel is /ʌ/, for Participant group is Monolingual Adults (in the) UK, and for Task type is (words produced in) Isolation. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	F_2 (normalised) (Hz)	
Target Vowel æ	128.882*	(76.298)
Target Vowel ɑː	−107.345	(77.360)
Target Vowel ɒ	−286.000***	(77.590)
Target Vowel ɜː	141.500*	(72.900)
Target Vowel iː	832.600***	(77.420)
Target Vowel ɪ	578.000***	(71.640)
Target Vowel ɔː	−300.100***	(74.670)
Target Vowel uː	206.400***	(73.260)
Target Vowel ʊ	39.110	(72.740)
Target Vowel ɛ	397.700***	(76.260)
Participant Group L2 Adults UK	28.070	(27.660)
Task Type Context	0.116	(15.940)
Intercept	1,910***	(57.130)
Observations	3,163	
Log Likelihood	−23,610	
Akaike Inf. Crit.	47,252	
Target Vowel æ : Participant Group L2 Adults UK	−157.600**	(68.040)
Target Vowel ɑː : Participant Group L2 Adults UK	239.774***	(73.083)
Target Vowel ɒ : Participant Group L2 Adults UK	−3.939	(69.949)
Target Vowel ɜː : Participant Group L2 Adults UK	−34.116	(67.510)
Target Vowel iː : Participant Group L2 Adults UK	−391.044***	(70.902)
Target Vowel ɪ : Participant Group L2 Adults UK	−247.044***	(67.113)
Target Vowel ɔː : Participant Group L2 Adults UK	179.197**	(71.207)
Target Vowel uː : Participant Group L2 Adults UK	−537.297***	(68.516)
Target Vowel ʊ : Participant Group L2 Adults UK	−196.294***	(68.200)
Target Vowel ɛ : Participant Group L2 Adults UK	−191.700***	(70.024)
Intercept	1,842***	(54.138)
Observations	3,163	
Log Likelihood	−23,462	
Akaike Inf. Crit.	46,975	

L2 Learners

Similarly to previous measures, subsequent models were developed for the factors that would be relevant to L2 Learners. The first factor to be added to the F_2 model was *Age*, which did not improve the model fit (p = .89) as per Table **??**, as was the case with the number of years of English exposure in the UK (p = .56) and in Greece (p = .49). More factors that did not contribute to the model fit was the age of onset of the L2 (p = .50) and the daily percentage of using English (p = .49) and Greek (p = .51), suggesting that factors that could affect L2 speech production did not have an effect on the productions of the group tested, as those did not differ significantly from monolingual norms.

Table 4.13: *The fixed effects (Target vowel, Participant groups, Task type, Age, L2 Age, Years of English exposure to Greece and the UK, and daily Percentage of English and Greek usage) in the linear mixed model for F_2 (Hz). The baseline for Target vowel is /ʌ/, for Participant group is Monolingual Adults (in the) UK, and for Task type is (words produced in) Isolation. ("***" p < 0.001, "**" p < 0.01, "*" p < 0.05, "." p < 0.1, " " p < 1)*

	Dependent variable:	
	F_2 (normalised) (Hz)	
Target Vowel æ	128.952*	(76.314)
Target Vowel ɑː	−107.261	(77.373)
Target Vowel ɒ	−285.880***	(76.600)
Target Vowel ɜː	141.649*	(72.916)
Target Vowel iː	832.646***	(77.434)
Target Vowel ɪ	578.013***	(71.649)
Target Vowel ɔː	−300.057***	(74.681)
Target Vowel uː	206.471***	(73.271)
Target Vowel ʊ	39.097	(72.752)
Target Vowel ɛ	397.723***	(76.277)
Participant Group L2 Adults UK	28.573	(28.346)
Age	1.877	(14.550)
Age of Onset to English	−1.539	(2.311)
Years of English exposure in the UK	0.953	(1.659)
Years of English exposure in Greece	2.553	(3.768)
L1 Percentage	−0.755	(1.160)
L2 Percentage	0.777	(1.136)
Task Type Context	0.146	(15.938)
Intercept	394.461***	(4.514)
Observations	3,163	
Log Likelihood	−17,587.770	
Akaike Inf. Crit.	35,207.540	

4.3.3 Vowel Spaces

Following the acoustical analysis of F_1, F_2, and vowel duration for both participant groups, the total acoustic space area was also calculated by using the total convex hull area as defined by all the vowels per participant group, using the R package "phonR" (McCloy, 2016). The acoustic vowel spaces for the two participant groups can be viewed in Figure **??**.

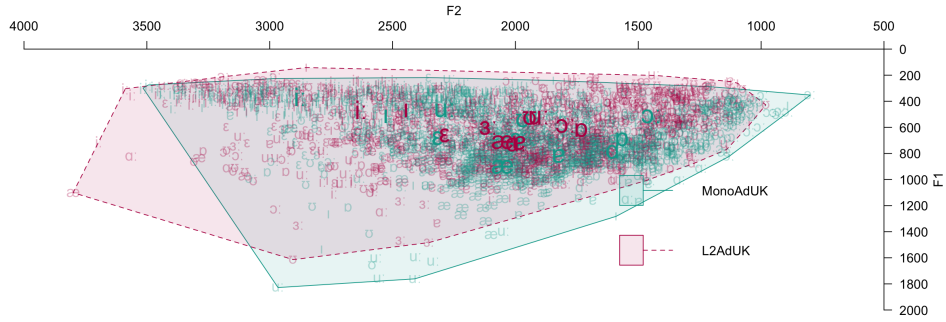


Figure 4.7: Vowel space area (in ERB^2) for adult L2 learners and monolingual controls

From the figure as well as from the obtained results it can be noted that the vowel productions of the control group occupied a larger acoustic space area ($115456 ERB^2$), compared to the L2 learner group, whose vowels occupied a smaller area ($66600 ERB^2$) by 73%.

4.4 Discussion

In this paper, I discussed how factors such as the size of phonemic inventories between two languages, as well as the organisation and comparison of phonetic categories in terms of features across language pairs can impact on L2 speech production. The focus of this study was to examine the productions of SSBE vowels by L2 Learners, especially for those phonemes which are represented with a single phonetic category in the L1. The reason I chose the Greek-English language pair was because the two differ substantially in a number of characteristics: vowel categories, vowel contrasts, and size. Specifically, the Greek system is a standard 5-vowel one (/i/, /ε/, /ɐ/, /o/ and /u/),[3] for which there is no tense/ lax vowel contrast, while duration is not a contrastive feature either, unless the vowel appears in a word-final position (Chapter 2) or is stressed (Dauer, 1980; Holton et al., 1997; Joseph & Philippaki-Warburton, 1987; Lengeris, 2009). On the contrary, BE has a more complex vowel system, both in terms of number of segments and in

[3]Please refer to Chapter 2 for a detailed description of the acoustic properties of Greek vowels

terms of the existence of contrasts (tense/ lax). Choosing this language pair would permit me to test the predictions of the two prominent models of L2 speech (SLM and PAM), as well as contribute to the debate of whether phonemic inventory sizes can affect L2 productions, by looking specifically at how learners who have experience in a small vowel inventory with few categories from their native language, can learn contrasts and new vowel categories that only exist in their L2.

To summarise, the SLM (Flege, 1992; 1995; 2005; Flege et al., 2020) predicts that new phonetic categories in the L2 are possible to be created by experienced L2 learners, even those who were first exposed to the L2 at a late stage, as the ability remains intact throughout the lifespan. What guides successful production of new categories though is the similarity or dissimilarity between native and non-native phonemes, as the greater the perceived dissimilarity, the easier it is for learners to form new categories and produce them in turn, in a native-like manner. The PAM (Best et al., 1988; Best & Strange, 1992; Best, 1995) predicts that perceptual similarity between L1 and L2 sounds can explain the discrimination ability of L2 learners. In other words, sounds which share acoustic characteristics might be assimilated to one category and be perceived as such, as opposed to sounds which are perceptually different, so they are more likely to be perceived as distinct categories. For instance, a contrast between /i/ - /ɪ/ has been documented to be hard for L2 learners of some languages, such as Spanish (Escudero & Boersma, 2004; Escudero, 2005; Morrison, 2009), Greek (Lengeris, 2009; Lengeris & Hazan, 2007), or Mandarin (Bohn, 1995), because there is no such distinction in the learners' L1; instead, there is only one category for both sounds.

To evaluate the study's hypotheses, I studied the production of SSBE vowels by native Greek L2 learners of English. To summarise, I hypothesised that L2 learners would be able to produce new L2 phonemic categories if there is substantial contrast between L1 and L2 categories or if there is one-to-one mapping of phonemes between the L1 and the L2, for instance /ɛ/ or /ɐ/. For pairs that are represented with two phonemic categories in the L2 (like /ɪ-i/ and /ʊ-u/) whilst there is only one phonemic category in the L1 (/i/ and /u/ respectively), I predicted that L2 learners may not be able to produce those in a native-like manner. What is expected instead, is assimilation of the two categories into one in the productions of L2 Learners, which would lead to an overlap between L1 and L2 categories. In terms of vowel duration in such contrasts, I predicted that tense vowels will be produced with longer durations than lax, as L2 learners whose L1 lacks tense and lax contrasts tend to rely on temporal cues to make the distinction between the categories, a pattern that could be replicated in production too (amongst others: Boersma & Escudero, 2008; Hacquard et al., 2007).

The participants were asked to respond to three production tasks involving picture naming of items containing tense/ lax contrasts (for instance, they were asked to name pictures of “sheep” (/ʃiːp/) and “ship” (/ʃɪp/), both in isolation and in fluent, connected speech, while their responses were being audio recorded. In order to respond to the question of how much space the vowels produced by L2 learners in comparison to monolingual controls occupy, I measured the frequencies of the first two formants (F_1 and F_2). The two correlates help position vowels on the $F_1 \times F_2$ vowel space, which would permit me to draw conclusions both on the positions of individual vowels on the acoustic/ phonetic space, but also use the measures to calculate the total vowel space area of L2 learners and monolingual controls, responding to the question of whether the space of learners whose native language has a small number of segments would produce as expanded vowel spaces as native speakers of a language with a large inventory. The third acoustic measure I analysed was Duration, which would help examine the hypothesis that L2 learners could be using temporal cues while perceiving tense/ lax vowel contrasts, which would manifest in the productions of tense vowels being longer.

Looking at each variable, the analysis of the formant frequencies showed that there were no significant differences in the vowel productions of L2 Learners and monolingual controls, which was an observation contrary to what was the initial hypothesis in this study, that L2 learners would produce “merged” like categories, including characteristics of both their L1 and L2. Although models of speech production predict the ability of experienced L2 learners to form new phonetic categories in their L2 despite late exposure, such conclusion has been drawn by experimental findings from L2 learners who had been exposed to an L2 for a several years at an immersion setting. The case of the learners in this study was that the majority of exposure to the L2 was done at an instructed setting in their native country and the years spent at an English-speaking environment were far less than what was documented in previous studies.

Another reason why it was surprising to obtain this result, was the fact that in the past it has been found that native speakers who are experienced in spectral contrasts from their L1, are able to employ those cues when they need to discriminate tense/ lax contrasts and they do so in production too (for instance, see Ainsworth, 1972; Hillenbrand, Clark, & Houde, 2000). On the contrary, speakers of languages for which the contrast does not exist, tend to rely on temporal cues when they are required to discriminate tense/ lax contrasts in a language that has those. This has been reported, for instance, in Spanish (Escudero & Boersma, 2004; Escudero, 2005; Morrison, 2009), Greek (Lengeris, 2009; Lengeris & Hazan, 2007), and Mandarin (Bohn, 1995). I would therefore expect to observe the difference in the duration results instead.

An alternative explanation to the findings though could be given through the predictions of the SLM model (Flege, 1992; 1995; 2005; Flege et al., 2020), in that it is possible that L2 learners were able to acquire and produce phonetic categories in the same way as monolinguals by demonstrating perception of vowels that do not exist in their native language. The fact that the learners were experienced in the L2 before coming to the UK, could have contributed to the total amount of exposure to BE, which could act as an explanatory factor for producing SSBE vowels in a native-like manner. The findings for F_1 and F_2 could not be interpreted through the PAM model though, as had the learners been assimilating contrasting vowels in single categories with shared characteristics from both the L1 and the L2, I would expect vowels to have been produced significantly different to monolinguals.

The final acoustic variable analysed was that of vowel duration. The analysis revealed that there were no significant differences in duration between L2 Learners and monolingual controls. As hypothesised earlier in the paper, I would expect L2 learners to produce tense vowels with longer durations, as speakers from languages with no tense/ lax distinctions use the feature of duration both as a perceptual cue and in their productions. I would attribute this finding again to the amount of exposure and usage of English.

Apart from vowel contrasts, I also wanted to explore the vowel spaces of L2 learners and BE monolingual controls. Overall, I observed that the vowel productions of native Greek L2 learners of English occupied a slightly larger vowel space area compared to that of the control group, however, not significantly different. I would expect that L2 Learners, having the influence of the vowel inventory size of Greek, which is smaller than SSBE, would produce a smaller vowel space to monolinguals. According to the theory of Adaptive Dispersion, the vowel categories of small phonemic inventories tend to have as much perceptual distance as possible between one another in order for the categories to be easily discernible (Liljencrants & Lindblom, 1972; Diehl et al., 2003, and others). In Greek, this holds partially true, as although most of the categories do not overlap, the back vowels seem to be closer together (Jongman et al., 1989). I would further expect that when the native

Greek L2 learners of English need to accommodate all the categories of a new, larger system, they would possibly be required to expand their perceptual space to do so, but this is deemed a difficult feat, as the spectral differences between L1 and L2 categories are often subtle.

Chapter 5

General Discussion

The main objective of the work presented in this thesis was to explore learning sounds in a new language by specifically looking at the effects of linguistic environment and phonological inventories on vowel production. From a developmental point of view, early on in life and within their first year, monolingual infants are able to perceive phonemic contrasts (Dietrich et al., 2007; Mani & Plunkett, 2010; Mani et al., 2008, Swingley, 2003); the same is observed for bilingual infants somewhat later, around 18 months (for instance, see Ramon-Casas, 2009), presumably because it takes longer to establish categories in both languages. Perceptual sensitivity in phonemic contrasts is found to have a positive effect in production too (Moyer, 2001; Vihman, 1999; 2002), which is what this work examined, by specifically delving into the productions of familiar words by bilingual children and second language learners.

Previous work has investigated phonemic contrasts of individual phonemes and has done so by examining the processing mechanisms involved in infancy. Extending existing work around phonemic categories, I was interested in identifying what happens in terms of production of vowels which have contrasting features such as tenseness and laxness for simultaneous and early sequential bilinguals as well as second language learners. I did so by looking at the vowel productions of the different groups in British English. thus examined the The focus of this research was the impact of the linguistic environment bilinguals grow up in as a potential factor affecting the amount and quality of input they received, therefore shaping their production patterns in one of their languages (Chapter 3). I also wanted to explore further the influence of the phonological systems in general, as a factor posing difficulties in establishing phonetic categories, especially later in life (Chapter 4). I chose the language pair of Greek and English as two systems that differ in their phonemic inventories in terms of size, organisation, and features. As there is no recent satisfactory description of the Greek vowel inventory due to the fact that previous studies were either based on introspective descriptions or had methodological issues, I chose to provide an up-to-date description of the system first, in order to use it as tool for the representation of the vowels in this work (Chapter 2).

In order to explore the topics stated earlier, a number of participant groups completed the tasks in question; to obtain acoustic data for Greek, which were used to reconstruct the phonetic/ auditory vowel space of the language and to provide descriptions for the system's vowels, a group of native Greek adults was asked to produce all 5 Greek vowels in a controlled environment (CVCV frames). To evaluate the effect of linguistic environment on the production of British English vowels, two groups of Greek-English bilingual children, based in Greece and in the UK were tested in structured and semi-structured elicitation tasks, during which they were asked to produce familiar English words represented by pictures, in isolation and in context, containing the vowels of interest. Their responses were compared to monolingual British English children residing in the UK. Finally, in order to explore the learning of phonemic contrasts, which, are absent from inventory of their native language, a group of native Greek second language learners of English were tested by means of the same structured and semi-structured elicitation tasks that the children groups completed. The amount of exposure, amount and quality of language input, and confidence in receptive and productive skills were evaluated with the use of language background questionnaires.

In terms of experimental procedure, a series of structured and semi-structured elicitation tasks were designed for the study of the tense/ lax vowel contrasts, all of which required the participants to name series of pictures. The test items to obtain the acoustic data were pictures representing familiar words in English. All test items were CVC or CVCV words containing tense or lax English vowels within consonant frames and were always found in the focus position. All the participant groups took part in those speech production tasks, while their responses were being audio recorded. From the responses obtained I analysed the acoustic measures of the first two formant frequencies and vowel duration, as all are relevant acoustic correlates in the production of tense and lax vowel contrasts (Hillenbrand et al., 2000; 2001; Stephens, 1998).

To obtain acoustic data for the Greek vowels, the test items comprised consonant frames with the same vowel on either side of the frame (CVCV sequences), making up nonsense words incorporated in a carrier phrase. The vowels were presented in nonsense words and stress was not marked, aiming at a neutral, as much as possible, production in order to confirm that there are no length distinctions in Greek vowels, unless they are found in stressed syllables, in which case vowels are found to have both longer durations and higher intensity (Dauer, 1980; Holton et al., 1997; Joseph & Philippaki-Warburton, 1987; Lengeris, 2009). It is possible though that the vowels appearing at the end of the frame were produced with a degree of stress, due to the iambic stress pattern of Greek (Joseph & Philippaki-Warburton, 1987; Newton, 1972), therefore tested for frame position effects in the production of greek vowels too. All data were acoustically analysed in terms of formants and duration, both being relevant cues in the discrimination and production of tense/ lax contrasts (Maye et al., 2002; Vihman, 2002). For Greek vowels, I also analysed vowel intensity, as an acoustic correlate to address whether stressed vowels are longer or have higher intensity in Greek. Using the measurements for the first two formants I also calculated the Euclidian distance among vowels on the phonetic space as well as the total vowel space area, in order to draw conclusions for the system's organisation.

To summarise the findings of the first study (Chapter 2), I would argue that largely, the high front and back vowels are in line with previous accounts on Greek. The two vowels for which controversy arose on their status (/ɛ/ and /ɐ/) , were found to be low-mid open and open near-low central vowel respectively. The findings for /ɛ/ are in line with the accounts that placed it in the low-mid area of the quadrilateral (for instance, Arvaniti, 2007) and not earlier transcriptions (/e/) suggesting a higher and more closed vowel (Botinis, 1981; Fourakis et al., 1999).

Due to the fact that the IPA system does not account successfully for the symbolical representation of low central vowels, especially in small inventories, the symbol /ɐ/ is going to be used as the most accurate alternative. By using this symbol, the phoneme's description is in line with that of Arvaniti (2007), and against descriptions provided earlier by Joseph and Philippaki-Warburton (1987), who placed the vowel lower and further back in the quadrilateral. In terms of duration and intensity, vowels in the frame-final position, although unstressed, appeared longer and with higher intensities, in line with Fry (1955), who wrote about perceived length and intensity for stressed Greek vowels, as well as Dauer (1980) and Joseph and Philippaki-Warburton (1987), although more recent accounts have claimed that stress is manifested by higher intensities only and not length (Lengeris 2009; Lengeris & Hazan, 2007). Finally, adding to the discussion of vowel dispersion in a language's inventory, in line with theories that predict clear boundaries, maximal distances and little to no overlap between categories for small phonemic inventories (Jongman et al., 1989; Lee & Zee, 2011; Liljencrants & Lindblom, 1972; Livijn, 2000; Trudgill, 2009), this was also found in the Greek data.

The vowel categories populating the Greek system exist in English as well: like in Greek, there are high and mid front vowels, low central vowels, as well as mid back and high back rounded vowels. However, tense and lax vowels are not a feature of Greek, which is the case in English and is a new feature that needs to be learnt by second language speakers. For the adult native Greek second language learners of English, tenseness and laxness proved to be difficult to produce, especially in terms of duration. Although duration is one of the correlates in tense and lax vowels, it also seems to be a cue that second language learners cannot produce effectively, as both tense and lax vowels in this study were produced with durations that were only marginally different, which was not confirmed statistically though.

This observation could be attributed to the fact that there are no short and long vowels in their native language, a distinction which, as mentioned earlier, is only present when the vowels are stressed. Although second language learners have been found able to use duration as a cue when perceiving tense and lax contrasts, even though the contrast is not present in their native language (for instance, see Bohn, 1995; Escudero, 2006; Escudero & Boersma, 2004; Morrison, 2009 for Spanish, Lengeris, 2009 and Lengeris & Hazan, 2007 for Greek, and Bohn, 1995 for Mandarin), the participants in this study do not seem to transfer the same ability in their productions. The finding is in line with the PAM model (Best, 1995), according to which second language learners assimilate new phonemes to the most perceptually similar alternative. If this holds true for the Greek learners, they seem to be assimilating the vowels to the closest native language categories.

When it came to analysing the data of the bilingual children, the latter were found to produce SBE vowels following British English monolingual norms. Specifically, and surprisingly so, the productions of the bilingual children based in Greece seemed to resemble the phonological norms of monolingual controls in the UK as opposed to the bilingual children based in the UK, whose productions were different to those of monolinguals and their Greece-based peers. A number of factors related to the input the bilingual groups were receiving could be explanatory factors of the findings. For instance, the numbers of years of exposure to English and Greek were found to affect the children's vowel productions as did the place of residence. It is worth considering that English input for the participants in Greece was not only received in school, where the medium of instruction was in British English, but also through peer interactions and at home, as in the majority of cases there was an English-speaking parent who was providing input in English. The finding contributes to a body of literature that not only quantity of input, but also quality, through the environment bilinguals are exposed to, are important in bilingual language development (for instance, see Driessen, Van der Slik, & De Bot, 2002; Palermo, Mikulski, Fabes, Hanish, Martin, & Stargel, 2014; Place & Hoff, 2011; Unsworth, 2016).

Bilingual children in Greece were also found to follow monolingual norms in producing British English vowels. Second language learners of English, surprisingly, demonstrated the same both in terms of spectral differences, as they were able to produce vowel tokens in a similar manner to what monolingual controls did, and in terms of temporal characteristics. This finding for the second language learners could mean that phonetic categories are still learnable in adulthood providing naturalistic input is received, and are able to be formed and produced successfully, especially for those categories that do not exist in the learners' native language, as it has also been predicted by the SLM (Flege, 1992; 1995; 2005). It is also worth considering though that L2 learners of English had lived in an English-speaking country for some time when tested, which might also be a contributory factor to their productions.

5.1 Conclusions

The present study examined the productions of British English vowel contrasts by bilingual children growing up in Greece and the UK, as well as the productions of native Greek second language learners of English residing in the UK, by looking at how the linguistic environment and phonemic inventories of their two languages might affect the phonological form of familiar words in English. To test the productions of the SSBE vowels, both the children and adult groups took part in the same picture naming elicitation tasks, during which they were asked to produce words in isolation and in context. In order to provide an up-to-date description of the Greek vowel system, which would be necessary in order to identify similarities and differences between the two systems, the Greek native speakers also took part in a vowel production task in Greek, during which they were asked to produce all Greek vowels in consonant frames.

As seen in this study, the focus was production of vowel contrasts, which are seen as "hard" or "novel", especially for second language learners who are not experienced in these contrasts from their native language. From a bilingual perspective, I explored the role of linguistic environment and whether it facilitates or hinders the production of those contrasts. The research methods used permitted the participants to produce isolated words at will in two of the three tasks, while a degree of spontaneity was only observed in the last task. However, the repetition of test items across tasks also meant that a degree of planning and preparation could have occurred in anticipation of the next test item to be presented, which could have affected the speakers' productions by rendering them more "refined" or "target-like", even though the words might have not been produced in the same way in spontaneous speech. Using free production tasks could have provided us with more spontaneous productions of the same target stimuli, although in that case it would have been hard to control the amount of tokens produced by each participant, which might have given us unbalanced data.

Another area that could be addressed in future studies is that of the processing mechanisms underlying the identification and discrimination of vowel contrasts. So far, I demonstrated that SSBE vowels can be produced by both bilinguals and second language learners as monolingual controls did. In both cases though, the participants were experienced and had received a substantial amount of input in English at a naturalistic setting; bilingual children were either growing up in a predominantly British English-speaking environment, the UK, and were receiving such input by their peers, school environment, and societal language, or they were spending several hours a day interacting in English at school and with peers, even though the language they were exposed to the rest of the day was Greek. For the second language learners, substantial experience with English was also reported, as in addition to having a high level of proficiency after receiving several years of English instruction in Greece, they had also spent at least three years in the UK. Therefore, the amount of input and possibly the fact that some of the exposure to the L2 was done at a naturalistic setting, are contributing factors to their performance. However, it would also be interesting to assess the perception of tense and lax contrasts to complement the observations made for production.

References

Adank, P., Smits, R., & Van Hout, R. (2004). A comparison of vowel normalization procedures for language variation research. *The Journal of the Acoustical Society of America, 116(5)*, 3099-3107.

Adank, P., Van Hout, R., & Velde, H. V. D. (2007). An acoustic description of the vowels of northern and southern standard Dutch II: Regional varieties. *The Journal of the Acoustical Society of America, 121(2)*, 1130-1141.

Ainsworth, W. A. (1972). Duration as a cue in the recognition of synthetic vowels. *The Journal of the Acoustical society of America, 51*(2B), 648-651.

Alizadeh, M. (2016). The impact of motivation on English language learning. *International Journal of Research in English Education, 1*(1), 11-15.

Amengual, M. (2011). Spanish and Catalan in Majorca: Are there contact-induced changes in the Catalan vowel system? In *Selected proceedings of the 13th Hispanic linguistics symposium*, 214-223.

Amengual, M., & Chamorro, P. (2015). The effects of language dominance in the perception and production of the Galician mid vowel contrasts. *Phonetica, 72*(4), 207-236.

Aoyama, K., & Flege, J. E. (2011). Effects of L2 experience on perception of English /r/ and /l/ by native Japanese speakers. *Journal of the Phonetic Society of Japan, 15*(3), 5-13.

Armon-Lotem, S., & Meir, N. (2019). The nature of exposure and input in early bilingualism. In A. De Houwer & L. Ortega (Eds.), The Cambridge handbook of bilingualism (pp. 193–212). Cambridge, UK: Cambridge University Press.

Arvaniti, A. (1999). Standard Modern Greek. *Journal of the International Phonetic Association, 29(2),* 167-172.

Arvaniti, A. (2000). The phonetics of stress in Greek. *Journal of Greek Linguistics, 1(1),* 9-39.

Arvaniti, A. (2007). Greek Phonetics: The State of the Art. *Journal of Greek linguistics, 8(1)*, 97-208.

Asher, J. J., & García, R. (1969). The optimal age to learn a foreign language. *The Modern Language Journal, 53*(5), 334-341.

Bailey, T. M., & Plunkett, K. (2002). Phonological specificity in early words. *Cognitive Development, 17*(2), 1265-1282.

Baltazani, M. (2006). Focusing, prosodic phrasing, and hiatus resolution in Greek. *Laboratory phonology, 8*, 473-494.

Baltazani, M. (2007). Prosodic rhythm and the status of vowel reduction in Greek. *Selected papers on theoretical and applied linguistics, 17*(1), 31-43.

Baltazani, M., Fudos, I., Kainada, E., Kappa, I., Lengeris, A., Mattheoudakis, M., Mikros, G., Nicolaidis, K., Papazachariou, D., Revithiadou, A., Topintzi, N. & Tzakosta, M. (2013). Vocalect: A Thalis project for the analysis of dialectal vocalic systems. *In 11th International Conference on Greek Linguistics, ICGL11* (pp. 26-29).

Barry, W. J., & Trouvain, J. (2008). Do we need a symbol for a central open vowel?. *Journal of the International Phonetic Association*, 349-357.

Bertinetto, P. M., & Loporcaro, M. (2005). The sound pattern of Standard Italian, as compared with the varieties spoken in Florence, Milan and Rome. *Journal of the International Phonetic Association, 35*(2), 131-151.

Best, C. T. (1995). A direct realist view of cross-language speech perception. *Speech perception and linguistic experience*, 171-206.

Best, C. C., & McRoberts, G. W. (2003). Infant perception of non-native consonant contrasts that adults assimilate in different ways. *Language and speech, 46*(2-3), 183-216.

Best, C. T., McRoberts, G. W., & Goodell, E. (2001). Discrimination of non-native consonant contrasts varying in perceptual assimilation to the listener's native phonological system. *The Journal of the Acoustical Society of America, 109*(2), 775-794.

Best, C. T., McRoberts, G. W., & Sithole, N. M. (1988). Examination of perceptual reorganization for nonnative speech contrasts: Zulu click discrimination by English-speaking adults and infants. *Journal of experimental psychology: human perception and performance, 14*(3), 345.

Best, C. T., & Strange, W. (1992). Effects of phonological and phonetic factors on cross-language perception of approximants. *Journal of phonetics, 20*(3), 305-330.

Best, C. T., & Tyler, M. D. (2007). Nonnative and second-language speech perception: Commonalities and complementarities. In M. J. Munro & O.-S. Bohn (Eds.), *Language experience in second language speech learning: In honor of James Emil Flege* (pp. 13-34). Amsterdam: John Benjamins.

Birdsong, D. (2014). Dominance and age in bilingualism. *Applied Linguistics, 35*(4), 374-392.

Birdsong, D., Gertken, L. M., & Amengual, M. (2012). Bilingual language profile: An easy-to-use instrument to assess bilingualism. *COERLL, University of Texas at Austin.*

Bley-Vroman, R. (1989). What is the logical problem of foreign language learning? In Gass, S. and Schachter, J., (Eds.), Linguistic perspectives on second language acquisition. Cambridge: Cambridge University Press, 41-68.

Bloch, B., & Trager, G. L. (1942). Outline of linguistic analysis. *Special Publications of the Linguistic Society of America.*

Boersma, P., & Weenink, D. (2006). Praat: Doing phonetics by computer [Computer software], University of Amsterdam, Amsterdam, The Netherlands.

Boersma, P., & Escudero, P. (2008). Learning to perceive a smaller L2 vowel inventory: an Optimality Theory account. *Contrast in phonology: Theory, perception, acquisition*, 271-301.

Bohn, O. S. (1995). Cross-language speech perception in adults: First language transfer doesn't tell it all. *Speech perception and linguistic experience: Issues in cross-language research*, 279-304.

Bohn, O. S., & Flege, J. E. (1990). Interlingual identification and the role of foreign language experience in L2 vowel perception. *Applied psycholinguistics, 11*(3), 303-328.

Bondarko, L. V. (1998). Fonetika sovremennogo russkogo jazyka [Phonetics of the modern Russian language]. *St. Petersburg, Russia: St. Petersburg University.*

Bortfeld, H., Morgan, J. L., Golinkoff, R. M., & Rathbun, K. (2005). Mommy and me: Familiar names help launch babies into speech-stream segmentation. *Psychological science, 16*(4), 298-304.

Bosch, L., & Sebastián-Gallés, N. (2003). Simultaneous bilingualism and the perception of a language-specific vowel contrast in the first year of life. Language and speech, 46(2-3), 217-243.

Botinis, A. (1981). The Greek Vowels. *Working Papers in Linguistics-Phonetics, 21*, 29-36.

Botinis, A. (1989). Stress and prosodic structure in Greek. Lund: Lund University Press.

Botinis, A., Fourakis, M., & Hawks, J. W. (1997). A perceptual study of the Greek vowel space using synthetic stimuli. *In Fifth European Conference on Speech Communication and Technology.*

Bouferroum, O., & Boudraa, M. (2015). CV coarticulation, locus and locus equation perspective on the invariance issue involving Algerian Arabic consonants. *Journal of Phonetics, 50*, 120-135.

Bradlow, A. R. (1995). A comparative acoustic study of English and Spanish vowels. *The Journal of the Acoustical Society of America, 97*(3), 1916-1924.

Bunton, K., & Leddy, M. (2011). An evaluation of articulatory working space area in vowel production of adults with Down syndrome. *Clinical linguistics & phonetics, 25*(4), 321-334.

Byers-Heinlein, K., Schott, E., Gonzalez-Barrero, A. M., Brouillard, M., Dube, D., Jardak, A., ... & Tamayo, M. P. (2020). MAPLE: A multilingual approach to parent language estimates. *Bilingualism: Language and Cognition, 23*(5), 951-957.

Catford, J. C. (1990). A proposal concerning central vowels. *Journal of the International Phonetic Association, 20*(2), 26-28.

Cebrian, J. (2007). Old sounds in new contrasts: L2 production of the English tense-lax vowel distinction. In *Poster presented at the 16th International Congress of Phonetic Sciences, Universität des Saarlandes, Germany.*

Chomsky, N., & Halle, M. (1968). The sound pattern of English.

Clopper, C. G., Pisoni, D. B., & De Jong, K. (2005). Acoustic characteristics of the vowel systems of six regional varieties of American English. *The Journal of the Acoustical society of America, 118(3),* 1661-1676.

Cohn, A. C. (1993). Nasalisation in English: phonology or phonetics. *Phonology, 10*(1), 43-81.

Conboy, B. T., & Mills, D. L. (2006). Two languages, one developing brain: Event?related potentials to words in bilingual toddlers. *Developmental science, 9*(1), F1-F12.

Conboy, B., Rivera-Gaxiola, M., Klarman, L., Aksoylu, E., & Kuhl, P. K. (2005). Associations between native and nonnative speech sound discrimination and language development at the end of the first year. In Supplement to the proceedings of the 29^{th} Boston University conference on language development.

Cook, V. J. (1977). Cognitive processes in second language learning. *International Review of Applied Linguistics, 15*(1), 1-20.

Core, C. (2012). Assessing phonological knowledge. *In E. Hoff (Ed.), Research Methods in Child Language. A practical Guide*, 79-99.

Council of Europe. Council for Cultural Co-operation. Education Committee. Modern Languages Division. (2001). *Common European Framework of Reference for Languages: learning, teaching, assessment.* Cambridge University Press.

Cutler, A., Mehler, J., Norris, D., & Segui, J. (1989). Limits on bilingualism. *Nature, 340*(6230), 229-230.

Cutler, A., Mehler, J., Norris, D., & Segui, J. (1992). The monolingual nature of speech segmentation by bilinguals. *Cognitive psychology, 24*(3), 381-410.

Curtiss, S., Fromkin, V., Krashen, S., Rigler, D., & Rigler, M. (1974). The linguistic development of Genie. *Language*, 528-554.

Dauer, R. M. (1980). The reduction of unstressed high vowels in Modern Greek.

Journal of the International Phonetic Association, 10(1/2), 17-27.

de Boysson-Bardies, B., Hallé, P., Sagart, L., & Durand, C. (1989). A crosslinguistic investigation of vowel formants in babbling. *Journal of child language, 16*(1), 1-17.

DeKeyser, R. M. (2000). The robustness of critical period effects in second language acquisition. *Studies in second language acquisition, 22*(4), 499-533.

DeKeyser, R. M. (2009). Cognitive-psychological processes in second language learning. The handbook of language teaching, 119, 138.

Department for Education (DfES). (2006). Primary national strategy: Primary framework for literacy and mathematics. DfES.

Diehl, R. L., Lindblom, B., & Creeger, C. P. (2003). Increasing realism of auditory representations yields further insights into vowel phonetics. In *Proceedings of the 15^{th} international congress of phonetic sciences* (Vol. 2, pp. 1381-1384).

Dietrich, C., Swingley, D., & Werker, J. F. (2007). Native language governs interpretation of salient speech sound differences at 18 months. *Proceedings of the National Academy of Sciences, 104*(41), 16027-16031.

Disner, S. F. (1978). Vowels in Germanic languages. Phonetics Laboratory, Department of Linguistics, UCLA.

Disner, S. F. (1984). Insights on vowel spacing. In Ian Maddieson, Patterns of sounds, 136-55.

Driessen, G., Van der Slik, F., & De Bot, K. (2002). Home language and language proficiency: A large-scale longitudinal study in Dutch primary schools. *Journal of Multilingual and Multicultural Development, 23*(3), 175-194.

Duckworth, M., Allen, G., Hardcastle, W., & Ball, M. (1990). Extensions to the International Phonetic Alphabet for the transcription of atypical speech. *Clinical Linguistics & Phonetics, 4*(4), 273-280.

Eisenbeiss, S. (2009). Contrast is the name of the game: contrast-based semi-structured elicitation techniques for studies on children's language acquisition.

Escudero, P. (2005). *Linguistic perception and second language acquisition: Explaining the attainment of optimal phonological categorization.* Netherlands Graduate School of Linguistics.

Escudero, P. (2006). The phonological and phonetic development of new vowel contrasts in Spanish learners of English. *English with a Latin Beat: Studies in Portuguese/ Spanish-English Interphonology*, 31, 41.

Escudero, P., & Boersma, P. (2004). Bridging the gap between L2 speech perception research and phonological theory. *Studies in Second Language Acquisition*, 551-585.

Fennell, C. T., Byers-Heinlein, K., & Werker, J. F. (2007). Using speech sounds to guide word learning: The case of bilingual infants. *Child development, 78*(5), 1510-1525.

Flege, J. E. (1992). Speech learning in a second language. *Phonological development: Models, research, implications*, 565, 604.

Flege, J. E. (1995). Second language speech learning: Theory, findings, and problems. *Speech perception and linguistic experience: Issues in cross-language research, 92,* 233-277.

Flege, J. E. (2003). Assessing constraints on second-language segmental production and perception. *Phonetics and phonology in language comprehension and production: Differences and similarities, 6,* 319-355.

Flege, J. E. (2005). Origins and Development of the Speech Learning Model. Keynote lecture presented at the 1^{st} ASA Workshop on L2 Speech Learning.

Flege, J. E. (2007). Language contact in bilingualism: Phonetic system interactions. *Laboratory phonology, 9,* 353-382.

Flege, J. E. (2016). The role of phonetic category formation in second language speech acquisition. In *Eighth International Conference on Second Language Speech* (Vol. 10).

Flege, J. E., Aoyama, K., & Bohn, O. S. (2020). The revised Speech Learning Model (SLM-r) applied. Manuscript submitted for publication.

Flege, J. E., Bohn, O. S., & Jang, S. (1997). Effects of experience on non-native speakers' production and perception of English vowels. *Journal of phonetics, 25*(4), 437-470.

Flege, J. E., James, A. R., & Leather, J. (1996). Second-language speech: Structure and process.

Flege, J. E., MacKay, I. R., & Piske, T. (2002). Assessing bilingual dominance. *Ap-*

plied Psycholinguistics, 23(4), 567-598.

Flege, J. E., MacKay, I. R., & Meador, D. (1999). Native Italian speakers' perception and production of English vowels. *The Journal of the Acoustical Society of America, 106*(5), 2973-2987.

Flege, J. E., Yeni-Komshian, G. H., & Liu, S. (1999). Age constraints on second-language acquisition. *Journal of memory and language, 41*(1), 78-104.

Fourakis, M., Botinis, A., & Katsaiti, M. (1999). Acoustic Characteristics of Greek Vowels. *Phonetica, 56(1-2)*, 28-43.

Fox, R. A., Flege, J. E., & Munro, M. J. (1995). The perception of English and Spanish vowels by native English and Spanish listeners: A multidimensional scaling analysis. *The Journal of the Acoustical Society of America, 97*(4), 2540-2551.

Frieda, E. M., & Nozawa, T. (2007). You are what you eat phonetically: The effect of linguistic experience on the perception of foreign vowels. *Second Language Speech Learning: In honor of James Emil Flege*, 79-96.

Fry, D. B. (1955). Duration and intensity as physical correlates of linguistic stress. *The Journal of the Acoustical Society of America, 27(4)*, 765-768.

Garcia-Sierra, A., Rivera-Gaxiola, M., Percaccio, C. R., Conboy, B. T., Romo, H., Klarman, L., Ortiz, S., & Kuhl, P. K. (2011). Bilingual language learning: An ERP study relating early brain responses to speech, language input, and later word production. *Journal of Phonetics, 39*(4), 546-557.

Georgiou, G. P. (2019). Bit and beat are heard as the same: Mapping the vowel perceptual patterns of Greek-English bilingual children. *Language Sciences, 72*, 1-12.

Gervain, J., & Mehler, J. (2010). Speech perception and language acquisition in the first year of life. *Annual review of psychology, 61*, 191-218.

Glasberg, B. R., & Moore, B. C. (1990). Derivation of auditory filter shapes from notched-noise data. *Hearing research, 47(1-2)*, 103-138.

Golinkoff, R. M., Hirsh-Pasek, K., Cauley, K. M., & Gordon, L. (1987). The eyes have it: Lexical and syntactic comprehension in a new paradigm. *Journal of child language, 14*(1), 23-45.

Grijalva, C., Piccinini, P. E., & Arvaniti, A. (2013). The vowel spaces of Southern Californian English and Mexican Spanish as produced by monolinguals and bilinguals. *In Proceedings of Meetings on Acoustics ICA2013 (Vol. 19, No. 1, p. 060088).* Acoustical Society of America.

Grosjean, F. (1982). Life with two languages: An introduction to bilingualism. Harvard University Press.

Grosjean, F. (2008). Studying bilinguals. Oxford University Press.

Grosjean, F., & Li, P. (2013). The psycholinguistics of bilingualism. John Wiley & Sons.

Hacquard, V., Walter, M. A., & Marantz, A. (2007). The effects of inventory on vowel perception in French and Spanish: An MEG study. *Brain and language, 100*(3), 295-300.

Hammond, R. M. (2001). The Sounds of Spanish: Analysis and Application (with Special Reference to American English). Cascadilla Press, Somerville, MA.

Harris, J. W. (1967). Spanish phonology. Doctoral dissertation. Massachusetts Institute of Technology.

Hawks, J. W., & Fourakis, M. S. (1995). The perceptual vowel spaces of American English and Modern Greek: a comparison. *Language and speech, 38(3)*, 237-252.

Hillenbrand, J. M., Clark, M. J., & Houde, R. A. (2000). Some effects of duration on vowel recognition. *The Journal of the Acoustical Society of America, 108*(6), 3013-3022.

Hillenbrand, J. M., Clark, M. J., & Nearey, T. M. (2001). Effects of consonant environment on vowel formant patterns. *The Journal of the Acoustical Society of America, 109*(2), 748-763.

Hlavac, Marek (2018). stargazer: Well-Formatted Regression and Summary Statistics Tables. R package version 5.2.2. https://CRAN.R-project.org/package=stargazer

Holton, D., Mackridge, P., & Philippaki-Warburton, I. (1997). Greek: A comprehensive grammar of the modern language. Psychology Press.

International Phonetic Association & International Phonetic Association Staff. (1999). *Handbook of the International Phonetic Association: A guide to the use of the International Phonetic Alphabet.* Cambridge University Press.

International Phonetic Association (IPA). (2015). The international phonetic alphabet and the IPA chart. Full IPA chart. Retrieved September 10, 2020, from https://www.internationalphoneticassociation.org/content/full-ipa-chart

Iverson, P., & Evans, B. G. (2007). Learning English vowels with different first-language vowel systems: Perception of formant targets, formant movement, and duration. *The Journal of the Acoustical Society of America, 122*(5), 2842-2854.

Iverson, P., Kuhl, P. K., Akahane-Yamada, R., Diesch, E., Kettermann, A., & Siebert, C. (2003). A perceptual interference account of acquisition difficulties for non-native phonemes. *Cognition, 87*(1), 47-57.

Iverson, P., Wagner, A., & Rosen, S. (2016). Effects of language experience on pre-categorical perception: Distinguishing general from specialized processes in speech perception. *The Journal of the Acoustical Society of America, 139*(4), 1799-1809.

Jescheniak, J. D., & Levelt, W. J. (1994). Word frequency effects in speech production: Retrieval of syntactic information and of phonological form. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*(4), 824.

Johnson, J. S., & Newport, E. L. (1989). Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language. *Cognitive psychology, 21*(1), 60-99.

Jongman, A., Fourakis, M., & Sereno, J. A. (1989). The acoustic vowel space of Modern Greek and German. *Language and speech, 32*(3), 221-248.

Joseph, B. D., Philippaki-Warburton, I., (1987). *Modern Greek.* London: Croom Helm.

Joseph B. & Tserdanelis G. (2003). Modern Greek. *In Variationstypologie. Ein sprachtypologisches Handbuch zu den europäischen Sprachen in Geschichte und Gegenwart,* T. Roelcke (Ed.). Berlin, De Gruyter, pp. 823-836.

Jusczyk, P. W., & Aslin, R. N. (1995). Infants' detection of the sound patterns of words in fluent speech. *Cognitive psychology, 29*(1), 1-23.

Kaimaki, M. (2015). Voiceless Greek vowels. *In ICPhS.*

Kartushina, N., Frauenfelder, U. H., & Golestani, N. (2016). How and when does the second language influence the production of native speech sounds: A literature review. *Language Learning, 66*(2), 155-186.

Kivistö-de Souza, H., & Carlet, A. (2014). Vowel inventory size and the use of temporal cues in non-native vowel perception by Catalan and Danish EFL learners. In *Proceedings of the International Symposium on the Acquisition of Second Language Speech* (Vol. 5, pp. 322-336).

Knight, R. A. (2012). *Phonetics: A coursebook.* Cambridge University Press.

Kondaurova, M. V., & Francis, A. L. (2008). The relationship between native allophonic experience with vowel duration and perception of the English tense/lax vowel contrast by Spanish and Russian listeners. *The Journal of the Acoustical Society of America, 124*(6), 3959-3971.

Kontosopoulos, N. (2001). Dialektoi ke Idiomata tis Neas Ellinikis [Dialects and Idioms of Modern Greek]. Athens: Grigoris.

Kontosopoulos, N. (2011). Isoglosses of dialect phenomena in Modern Greek.

Neoellenike Dialectologia 6,165-173.

Kroll, J. F., & Bialystok, E. (2013). Understanding the consequences of bilingualism for language processing and cognition. *Journal of cognitive psychology, 25*(5), 497-514.

Kuhl, P. K. (1991). Human adults and human infants show a "perceptual magnet effect" for the prototypes of speech categories, monkeys do not. *Perception & psychophysics, 50*(2), 93-107.

Kuhl, P. K. (1992). Psychoacoustics and speech perception: Internal standards, perceptual anchors, and prototypes.

Kuhl, P. K. (1994). Learning and representation in speech and language. *Current opinion in neurobiology, 4*(6), 812-822.

Kuhl, P. K. (2004). Early language acquisition: cracking the speech code. *Nature reviews neuroscience, 5*(11), 831-843.

Kuhl, P. K., Conboy, B. T., Coffey-Corina, S., Padden, D., Rivera-Gaxiola, M., & Nelson, T. (2008). Phonetic learning as a pathway to language: new data and native language magnet theory expanded (NLM-e). *Philosophical Transactions of the Royal Society B: Biological Sciences, 363*(1493), 979-1000.

Kuhl, P. K., Conboy, B. T., Padden, D., Nelson, T., & Pruitt, J. (2005). Early speech perception and later language development: implications for the "Critical Period". *Language learning and development, 1*(3-4), 237-264.

Kuhl, P. K., & Meltzoff, A. N. (1996). Infant vocalizations in response to speech:

Vocal imitation and developmental change. *The journal of the Acoustical Society of America, 100*(4), 2425-2438.

Kuhl, P. K., Stevens, E., Hayashi, A., Deguchi, T., Kiritani, S., & Iverson, P. (2006). Infants show a facilitation effect for native language phonetic perception between 6 and 12 months. *Developmental science, 9*(2), F13-F21.

Kuhl, P. K., Tsao, F. M., & Liu, H. M. (2003). Foreign-language experience in infancy: Effects of short-term exposure and social interaction on phonetic learning. *Proceedings of the National Academy of Sciences, 100*(15), 9096-9101.

Kuhl, P. K., Williams, K. A., Lacerda, F., Stevens, K. N., & Lindblom, B. (1992). Linguistic experience alters phonetic perception in infants by 6 months of age. *Science, 255*(5044), 606-608.

Ladefoged, P. (2003). Phonetic data analysis: An introduction to instrumental phonetic fieldwork. Blackwell, Oxford.

Ladefoged, P., & Maddieson, I. (1996). The sounds of the world's languages (Vol. 1012). Oxford: Blackwell.

Lee, W. S., & Zee, E. (2011). Dispersion and variability of vowels of different inventory sizes. *The Journal of the Acoustical Society of America, 130*(4), 2520-2520.

Lengeris, A. (2016). Comparison of perception-production vowel spaces for speakers of Standard Modern Greek and two regional dialects. *The Journal of the Acoustical Society of America, 140(4),* 314-319.

Lengeris, A. (2009). Perceptual assimilation and L2 learning: Evidence from the perception of Southern British English vowels by native speakers of Greek and Japanese. *Phonetica, 66*(3), 169-187.

Lengeris, A., & Hazan, V. (2007). Cross-language perceptual assimilation and discrimination of Southern British English vowels by Greek and Japanese learners of English. In *Proceedings of ICPhS* (Vol. 16, pp. 1641-1644).

Lenneberg, E. H. (1967). The biological foundations of language. *Hospital Practice, 2*(12), 59-67.

Li, P., Sepanski, S., & Zhao, X. (2006). Language history questionnaire: A web-based interface for bilingual research. *Behavior research methods, 38(2)*, 202-210.

Li, P., Zhang, F., Tsai, E., & Puls, B. (2014). Language history questionnaire (LHQ 2.0): A new dynamic web-based research tool. *Bilingualism, 17(3)*, 673.

Liljencrants, J., & Lindblom, B. (1972). Numerical simulation of vowel quality systems: The role of perceptual contrast. *Language*, 839-862.

Lindblom, B. (1986). Phonetic universals in vowel systems. *Experimental phonology*, 13-44.

Livijn, P. (2000). Acoustic distribution of vowels in differently sized inventories? Hot spots or adaptive dispersion. *Phonetic Experimental Research, Institute of Linguistics, University of Stockholm (PERILUS)*, 11.

Llompart, M., & Reinisch, E. (2019). Robustness of phonolexical representations relates to phonetic flexibility for difficult second language sound contrasts. *Bilingualism: Language and Cognition, 22*(5), 1085-1100.

Lobanov, B. M. (1971). Classification of Russian vowels spoken by different speakers. *The Journal of the Acoustical Society of America, 49(2B)*, 606-608.

Long, M. H. (1990). Maturational constraints on language development. *Studies in second language acquisition, 12*(3), 251-285.

Mackridge, P. (1985). The Modern Greek language: A descriptive analysis of standard Modern Greek. Oxford University Press, USA.

Mackridge, P. (2010). Modern Greek. In Egbert J. Bakker (Ed.) *A Companion to the Ancient Greek Language*, 564-587, Wiley-Blackwell: West Sussex.

Maddieson, I., & Disner, S. F. (1984). *Patterns of sounds.* Cambridge: Cambridge University Press.

Mani, N., Coleman, J., & Plunkett, K. (2008). Phonological specificity of vowel contrasts at 18-months. *Language and speech, 51*(1-2), 3-21.

Mani, N., & Plunkett, K. (2007). Phonological specificity of vowels and consonants in early lexical representations. *Journal of Memory and Language, 57*(2), 252-272.

Mani, N., & Plunkett, K. (2010). Twelve-month-olds know their cups from their keps and tups. *Infancy, 15*(5), 445-470.

Marian, V., Blumenfeld, H. K., & Kaushanskaya, M. (2007). The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals. *Journal of Speech, Language, and Hearing Research*, 50: 940-967.

Mackay, I. R., Flege, J. E., & Imai, S. (2006). Evaluating the effects of chronological age and sentence duration on degree of perceived foreign accent. *Applied Psycholinguistics, 27*(2), 157-183.

McCloy, D. R. (2016). phonR: tools for phoneticians and phonologists. *R package version,* 1-0.

Marini, A., & Fabbro, F. (2007). Psycholinguistic models of speech production in Bilingualism and Multilingualism. *Speech and language disorders in bilinguals,* 47-67.

Maye, J., Werker, J. F., & Gerken, L. (2002). Infant sensitivity to distributional information can affect phonetic discrimination. *Cognition, 82*(3), B101-B111.

McMahon, A. (2002). *An introduction to English phonology.* Edinburgh University Press.

Meisel, I. M. (2001). The simultaneous acquisition of two frst languages. *Trends in bilingual acquisition, 1,* 11.

Mermelstein, P. (1978). On the relationship between vowel and consonant identification when cued by the same acoustic information. *Perception & Psychophysics, 23*(4), 331-336.

Meunier, C., Frenck-Mestre, C., Lelekov-Boissard, T., & Le Besnerais, M. (2003). Production and perception of vowels: does the density of the system play a role?, 723-726.

Molfese, D. L. (2000). Predicting dyslexia at 8 years of age using neonatal brain responses. *Brain and language, 72*(3), 238-245.

Molnar, M., Lallier, M., & Carreiras, M. (2014). The amount of language exposure determines nonlinguistic tone grouping biases in infants from a bilingual environment. *Language Learning, 64*(s2), 45-64.

Morrison, G. S. (2009). L1-Spanish Speakers' Acquisition of the English /i/-/ɪ/ Contrast II: Perception of Vowel Inherent Spectral Change1. *Language and Speech, 52*(4), 437-462.

Moyer, A. (2004). *Age, accent, and experience in second language acquisition: An integrated approach to critical period inquiry.* (Vol. 7). Multilingual Matters.

Moyer, A. (2011). An investigation of experience in L2 phonology: Does quality matter more than quantity?. *Canadian Modern Language Review, 67*(2), 191-216.

Munro, M. J., Flege, J. E., & MacKay, I. R. (1996). The effects of age of second language learning on the production of English vowels. *Applied psycholinguistics, 17*(3), 313-334.

Nakai, S., Beavan, D., Lawson, E., Leplêtre, G., Scobbie, J. M., & Stuart-Smith, J. (2018). Viewing speech in action: speech articulation videos in the public domain that demonstrate the sounds of the International Phonetic Alphabet (IPA). *Innovation in Language Learning and Teaching, 12*(3), 212-220.

Nance, C., McLeod, W., O'Rourke, B., & Dunmore, S. (2016). Identity, accent aim, and motivation in second language users: New Scottish Gaelic speakers? use of phonetic variation. *Journal of Sociolinguistics, 20*(2), 164-191.

Nearey, T. M. (1978). *Phonetic feature systems for vowels.* Doctoral dissertation, University of Alberta.

Newton, B. (1972). The generative interpretation of dialect: A study of Modern Greek phonology (Vol. 8). CUP Archive.

Nicolaidis, K. (2003). Acoustic Variability of Vowels in Greek Spontaneous Speech. *In Proceedings of the 15th international congress of phonetic sciences* (pp. 3221-3224).

Nicolaidis, K., & Rispoli, R. (2005). The effect of noise on speech production: an acoustic study. *Studies in Greek Linguistics, 25,* 415-426.

Okada, H. (1999). Japanese. *Handbook of the International Phonetic Association,* International Phonetic Association (Ed.), 117-119.

Oyama, S. (1976). A sensitive period for the acquisition of a non-native phonological system. *Journal of psycholinguistic research, 5*(3), 261-283.

Padgett, J., & Tabain, M. (2005). Adaptive dispersion theory and phonological vowel reduction in Russian. *Phonetica, 62*(1), 14-54.

Palermo, F., Mikulski, A. M., Fabes, R. A., Hanish, D., L., Martin, C., L., & Stargel, L. E. (2014). English exposure in the home and classroom: Predictions to Spanish-speaking preschoolers' English vocabulary skills. *Applied Psycholinguistics, 35*(6), 1163.

Papakyritsis, I., & Granese, A. (2013). Cross linguistic study of vowel systems.

Handbook of Vowels and Vowel Disorders, Psychology Press, New York, 186-206.

Papçun, G. (1976). How may vowel systems differ?. *UCLA Working Papers in Phonetics, 31*, 38-45.

Passy, P. (1888). Our revised alphabet. *The Phonetic Teacher*, 57.

Patkowski, M. S. (1990). Age and accent in a second language: A reply to James Emil Flege. *Applied linguistics, 11*(1), 73-89.

Peterson, G. E., & Barney, H. L. (1952). Control methods used in a study of the vowels. *The Journal of the acoustical society of America, 24(2)*, 175-184.

Piske, T. (2007). Implications of James E. Flege's research for the foreign language classroom. *Language experience in second language speech learning. In honor of James Emil Flege*, 301-314.

Place, S., & Hoff, E. (2011). Properties of dual language exposure that influence 2?year?olds' bilingual proficiency. *Child development, 82*(6), 1834-1849.

Polka, L., & Bohn, O. S. (2011). Natural Referent Vowel (NRV) framework: An emerging view of early phonetic development. *Journal of Phonetics, 39*(4), 467-478.

Polka, L., Colantonio, C., & Sundara, M. (2001). A cross-language comparison of /d/-/ð/ perception: evidence for a new developmental pattern. *The Journal of the Acoustical Society of America, 109*(5), 2190-2201.

Polka, L., & Werker, J. F. (1994). Developmental changes in perception of nonnative vowel contrasts. *Journal of Experimental Psychology: Human perception and performance, 20*(2), 421.

Ramon-Casas, M., Swingley, D., Sebastián-Gallés, N., & Bosch, L. (2009). Vowel categorization during word recognition in bilingual toddlers. *Cognitive psychology, 59*(1), 96-121.

Recasens, D. (2009). Response to WJ Barry & J. Trouvain, Do we need a symbol for a central open vowel? JIPA 38 (2008), 349-357. *Journal of the International Phonetic Association, 39*(2), 231-233.

Roach, P. (2004). British English: Received pronunciation. *Journal of the International Phonetic Association, 34*(2), 239-245.

Roach, P. (2009). The production of speech sounds. *English phonetics and Phonology: A Practical Course.*

Rodd, J., & Chen, A. (2016). Pitch accents show a perceptual magnet effect: Evidence of internal structure in intonation categories. *In Speech Prosody 2016.* 697-701.

Samaras, M. (1974). Study of the Influence of the Accent on Modern Greek Vowel Formant Structure. *Bulletin de l' Institut de Phonétique de Grenoble, 3*, 129-138.

Sapir, S., Ramig, L. O., Spielman, J. L., & Fox, C. (2010). Formant centralization ratio: A proposal for a new acoustic measure of dysarthric speech. *Journal of speech, language, and hearing research.*

Saranraj, L., & Shahila, Z. (2016). Motivation in Second Language Learning? A

Retrospect. *International Interdisciplinary Research Journal, 4*(1), 7-13.

Sfakianaki, A. (2002). Acoustic characteristics of Greek vowels produced by adults and children. *Selected papers on theoretical and applied linguistics, 14*, 383-394.

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika, 52*(3/4), 591-611.

Simonet, M. (2010). Dark and clear laterals in Catalan and Spanish: Interaction of phonetic categories in early bilinguals. *Journal of Phonetics, 38*(4), 663-678.

Slifka, J. (2003). Tense/lax vowel classification using dynamic spectral cues. In *Proceedings of the 15th ICPhS*. 921-924.

Souza, H. K. D., Carlet, A., J?ukowska, I. A., & Rato, A. (2017). Vowel inventory size matters: Assessing cue-weighting in L2 vowel perception. *Ilha do Desterro, 70*(3), 33-46.

Spencer, A. (1996). *Phonology: Theory and description* (Vol. 9). Wiley-Blackwell.

Stephens, K. N. (1998). Acoustic Phonetics. Cambridge, Massachusetts.

Sundara, M., Polka, L., & Genesee, F. (2006). Language-experience facilitates discrimination of /d-ð/ in monolingual and bilingual acquisition of English. *Cognition, 100*(2), 369-388.

Swingley, D. (2003). Phonetic detail in the developing lexicon. *Language and speech, 46*(2-3), 265-294.

Swingley, D. (2005). 11-month-olds' knowledge of how familiar words sound. *Developmental science, 8*(5), 432-443.

Swingley, D., & Aslin, R. N. (2000). Spoken word recognition and lexical representation in very young children. *Cognition, 76*(2), 147-166.

Tahta, S., Wood, M., & Loewenthal, K. (1981). Foreign accents: Factors relating to transfer of accent from the first language to a second language. *Language and Speech, 24*(3), 265-272.

Themistocleous, C. (2017). The nature of phonetic gradience across a dialect continuum: evidence from modern greek vowels. *Phonetica, 74*(3), 157-172.

Thomas, E. R., & Kendall, T. (2007). NORM: The vowel normalization and plotting suite. Online Resource. URL: http://lingtools.uoregon.edu/norm/norm1.php. Accessed: 20/03/2021

Triantafyllides, M. (1941). Neoelliniki Grammatiki [Modern Greek Grammar (of Demotic)]. Athens: Greek Government Schoolbook Press. 2nd edition (1978) Thessaloniki: Institute of Modern Greek Studies.

Trudgill, P. (2003). Modern Greek dialects: A preliminary classification. *Journal of Greek linguistics, 4(1),* 45-63.

Trudgill, P. (2009). Greek dialect vowel systems, vowel dispersion theory, and sociolinguistic typology. *Journal of Greek Linguistics, 9*(1), 165-182.

Tsao, F. M., Liu, H. M., & Kuhl, P. K. (2004). Speech perception in infancy predicts language development in the second year of life: A longitudinal study. *Child* *development, 75*(4), 1067-1084.

Tseva, A. (1988). Structure acoustique des voyelles du grec moderne: où en sont les connaissances? [Acoustic structure of the modern Greek vowels: where is the knowledge?]. *Bulletin de l' Institut de Phonétique de Grenoble, (17-18),* 87-107.

Tyler, M. D. (2019). PAM-L2 and Phonological Category Acquisition in the Foreign Language Classroom. *A Sound Approach to Language Matters: In Honor of Ocke-Schwen Bohn*, 607-630.

Unsworth, S. (2015). Quantity and quality of language input in bilingual language learning development. *Lifespan Perspectives on Bilingualism.* Berlin: Mouton de Gruyter.

Unsworth, S. (2015). Amount of exposure as a proxy for dominance in bilingual language acquisition. In C. Silva-Corvalan & J. Treffers-Daller (Eds.), *Language dominance in bilinguals: Issues of measurement and operationalization* (pp. 156-173). Cambridge: Cambridge University Press

Unsworth, S., Chondrogianni, V., & Skarabela, B. (2018). Experiential measures can be used as a proxy for language dominance in bilingual language acquisition research. *Frontiers in psychology, 9,* 1809.

Uribe Enciso, O. L., Hernandez, F., Smith, S., Pabón, R., & Steve, A. (2019). Problematic Phonemes for Spanish-Speakers' Learners of English. *GIST Education and Learning Research Journal, 19*, 215-238.

Veloso, J. (2017). Central, epenthetic, unmarked vowels and schwas: A brief outline of some essential differences. *Linguística: Revista de Estudos Linguísticos da*

Universidade do Porto, 5.

Vihman, M. M. (1999). The relationship between perception and production in early phonological development. In *Proceedings from the XIVth International Congress of Phonetic Sciences (ICPhS 99),* San Fransisco. 13-19.

Vihman, M. M. (2002). Getting started without a system: From phonetics to phonology in bilingual development. *International Journal of Bilingualism, 6*(3), 239-254.

Wells, J. C. (2006). Phonetic transcription and analysis. *Encyclopaedia of Language and Linguistics*. Amsterdam: Elsevier, 386-396.

Werker, J. F., & Tees, R. C. (1984). Cross-language speech perception: Evidence for perceptual reorganization during the first year of life. *Infant behavior and development, 7*(1), 49-63.

Wood, S. (1975). The weakness of the tongue-arching model of vowel articulation. Phonetics Lab. Lund University, *Working Papers, 11*, 55-108.

Yeni-Komshian, G. H., Flege, J. E., & Liu, S. (2000). Pronunciation proficiency in the first and second languages of Korean-English bilinguals. *Bilingualism: Language and cognition, 3*(2), 131-149.

Zhao, T. C., Masapollo, M., Polka, L., Ménard, L., & Kuhl, P. K. (2019). Effects of formant proximity and stimulus prototypicality on the neural discrimination of vowels: Evidence from the auditory frequency-following response. *Brain and language, 194*, 77-83.

Κριμπάς, Π. Γ. [Krimpas, P. G.]. (2019). Η επτανησιακή γεωγραφική γλωσσική ποικιλία της Νεοελληνικής: Μια ολιστική προσέγγιση [The Heptanesian Geographic Linguistic Variety of Standard Modern Greek: a Holistic Approach]. 14ο Διεθνές Συνέδριο Ελληνικής Γλωσσολογίας [14th International Conference of Greek Linguistics], 1(1), 646-660.

Appendix 1: Language Background Questionnaire for L2 Adults

Language Questionnaire

This questionnaire is designed to determine your language background

PART 1: Language Profile

Subject number: ____

Age: __________ Sex: ☐ Female ☐ Male

Country and place of birth: ______________________________________

Years lived in native country (from age ….. to age …..): ______________________

Years lived in foreign country (from age….. to age…..):______________________

If lived in more than one country, please specify (country/ duration):____________

Years of English language education in native country (specify country, total # of years, age): ____________

Type of English language education received (private lessons, school, etc.):_____________

Who taught English? Please specify (native English/ other):___________________

Years and type of English language education in another country (specify country, total # of years, age):

____

Known learning disabilities: ____

Current occupation:_________________________ level of study:_________________________

Please categorise yourself according to your language skills:

1 ☐ I speak and read only in English.

2 ☐ I speak and read in English and speak / read in one or more second language(s).

3 ☐ I am bilingual; I speak one of my second languages fluently (i.e. I am near-native).

4 ☐ I am bilingual; I learned two languages simultaneously when I was a child.

5 ☐ I am multilingual; I am fluent or near-native in two or more languages and know one or more languages in addition to my fluent ones.

Please fill in the age at which you started to learn, the learning situation (i.e., home, school, extended stay in a foreign country), and the present use for each of the languages you know. For example, you might write "English, birth, home, now everyday use" or for a second or further language, "French, 12, school, spoken at school/university."

Language: Age: Learning Situation: Present Use:

Native Language:

____

Second Language (or if bilingual, second fluent language):

____

Other Languages (list in order of fluency):

Language: Age: Learning Situation: Present Use:

____

____

____

____

Language Questionnaire

This questionnaire is designed to determine your language background

PART 2: Language Exposure & Self-Assessment

1. Please outline extensive stays (longer than two weeks) or times you lived in a country other than the native country. For example, you might write “Australia, 8 months when aged 2-3, English”

Country: Length of stay / age: Language spoken there:

____
____
____
____

Please rate your abilities in your native, second and other languages circling the appropriate number.

1. Reading

1=very difficult to read and understand normal texts (i.e., a newspaper article), 5=very easy to read and understand normal texts

a. Greek:

*_____*_____*_____*_____*
1 2 3 4 5

b. Second language:

*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________):

*_____*_____*_____*_____*
1 2 3 4 5

2. Writing

1=very difficult to express ideas correctly in writing, 5=very easy to express ideas in writing

a. Greek:

*_____*_____*_____*_____*
1 2 3 4 5

b. Second language:

*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________):

*_____*_____*_____*_____*
1 2 3 4 5

3. Listening

1=very difficult to understand normal spoken speech, 5=very easy to understand normal spoken speech

a. Greek:

*_____*_____*_____*_____*
1 2 3 4 5

b. Second language:

*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________):

*_____*_____*_____*_____*
1 2 3 4 5

4. Speaking
1=very difficult to formulate and verbalize natural-sounding sentences in conversation, 5=very easy to formulate and verbalize fluent sentences in conversation

a. Greek:
*_____*_____*_____*_____*
1 2 3 4 5

b. Second language:
*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________):
*_____*_____*_____*_____*
1 2 3 4 5

5. Pronunciation
1=I have a **very** distinct foreign accent when I speaks English, 5=People think I am a native English speaker when I speak

English:
*_____*_____*_____*_____*
1 2 3 4 5

6. Grammar
1=very difficult to understand how a sentence is put together, 5=very easy to form and understand the structure of sentences in any situation

a. Greek:
*_____*_____*_____*_____*
1 2 3 4 5

b. Second language:
*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________):
*_____*_____*_____*_____*
1 2 3 4 5

7. Language Independence
1=When I use this language, I always have to translate from my native language, 5=I feel totally independent in this language and can "think" in it.

a. Greek:
*_____*_____*_____*_____*
1 2 3 4 5

b. Second language:
*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________):
*_____*_____*_____*_____*
1 2 3 4 5

Language Preferences & Experience

1. Native language or fluent language 1: ________*Greek*________
Second language or fluent language 2: ________*English*_______
Other language (please specify): ___________________________

2. Which language do you use most in daily life?

☐ native language ☐ second language

Which language did you learn when you first learned to speak?

☐ native language ☐ second language ☐ both at the same time

☐ other situation (describe _______________________________________)

3. Native language of both parents and language spoken with that parent:

native language: language spoken:

Mother____

Father____

4. *If* you indicated that you acquired two languages during childhood, briefly describe the circumstances.

____

5. What language(s) do you speak at home or extensively with family or friends? With whom you speak the language?

Example: At home: Greek, with parents
With friends: English, at university

Language spoken at home: With whom:

____

____

Language spoken with friends: With whom:

____

____

6. In which setting is your native language most used?

☐ home ☐ surroundings/work ☐ both equally ☐ other (specify ________________)

7. Your second language?

☐ home ☐ surroundings/work ☐ both equally ☐ other (specify ________________)

8. What percentage of the day is each language used (spoken, reading, writing, thinking)?
Native language ________ Second language ___________ Other language_________________

9. Which language do you prefer to:

Speak in?

☐ native language ☐ second language ☐ other

Listen to?

☐ native language ☐ second language ☐ other

Read in?

☐ native language ☐ second language ☐ other

Write in?

☐ native language ☐ second language ☐ other

10. Regarding each language, at which age did you begin to (for your native language, just fill in a “0” if you acquired the language normally as a child):

Speak?
native language _______ second language _______ other _______

Understand spoken sentences?
native language _______ second language _______ other _______

Read?
native language _______ second language _______ other _______

Write?
native language _______ second language _______ other _______

11. How often do you switch from your native to second language, or visa versa?

1=Never switch languages, 5= Switch languages very frequently

*_____*_____*_____*_____*
1 2 3 4 5

12. How easy is it for you to switch from your native to second language, or visa versa?
1=very difficult to switch, 5=very easy to switch

*_____*_____*_____*_____*
1 2 3 4 5

13. Please add any additional information you feel is important for us to know below.

THANK YOU.

Appendix 2: Language Background Questionnaire for Monolingual British English Adults

Language Questionnaire

This questionnaire is designed to determine your language background

PART 1: Language Profile

Subject number: ____

Age: ________________ Sex: ☐ Female ☐ Male

Country and place of birth: ______________________________________

Years lived in native country (from age ….. to age …..): ______________________

Years lived in foreign country (from age….. to age…..):______________________

If lived in more than one country, please specify (country/ duration):____________

Years of English language education in native country (specify country, total # of years, age): ____________

Type of English language education received (private lessons, school, etc.):_____________

Who taught English? Please specify (native English/ other):___________________

Years and type of English language education in another country (specify country, total # of years, age):

____

Known learning disabilities: ______________________________________

Current occupation:__________________________ level of study:__________________________________

Please categorise yourself according to your language skills:

1 ☐ I speak and read only in English.

2 ☐ I speak and read in English and speak / read in one or more second language(s).

3 ☐ I am bilingual; I speak one of my second languages fluently (i.e. I am near-native).

4 ☐ I am bilingual; I learned two languages simultaneously when I was a child.

5 ☐ I am multilingual; I am fluent or near-native in two or more languages and know one or more languages in addition to my fluent ones.

Please fill in the age at which you started to learn, the learning situation (i.e., home, school, extended stay in a foreign country), and the present use for each of the languages you know. For example, you might write "English, birth, home, now everyday use" or for a second or further language, "French, 12, school, spoken at school/university."

Language: Age: Learning Situation: Present Use:

Native Language:

____

Second Language (or if bilingual, second fluent language):

____

Other Languages (list in order of fluency):

Language: Age: Learning Situation: Present Use:

____

____

____

____

Language Questionnaire
This questionnaire is designed to determine your language background

PART 2: Language Exposure & Self-assessment
1. Please outline extensive stays (longer than two weeks) or times you lived in a country other than the native country. For example, you might write "Australia, 8 months when aged 10-12, English"

Country: Length of stay / age: Language spoken there:
____
____
____
____

Please rate your abilities in English circling the appropriate number.

1. Reading
1=very difficult to read and understand normal texts (i.e., a newspaper article), 5=very easy to read and understand normal texts

a. English:
*____*____*____*____*
1 2 3 4 5

2. Writing
1=very difficult to express ideas correctly in writing, 5=very easy to express ideas in writing

a. English:
*____*____*____*____*
1 2 3 4 5

3. Listening
1=very difficult to understand normal spoken speech, 5=very easy to understand normal spoken speech

a. English:
*____*____*____*____*
1 2 3 4 5

4. Speaking
1=very difficult to formulate and verbalize natural-sounding sentences in conversation, 5=very easy to formulate and verbalize fluent sentences in conversation

a. English:
*____*____*____*____*
1 2 3 4 5

5. Grammar
1=very difficult to understand how a sentence is put together, 5=very easy to form and understand the structure of sentences in any situation

a. English:
*____*____*____*____*
1 2 3 4 5

Language Preferences & Experience

Native language or fluent language 1: ________*English*________

Please add any additional information you feel is important for us to know below.

THANK YOU.

Appendix 3: Language Background Questionnaire for Monolingual British English Adults with knowledge of an L2

Language Questionnaire

This questionnaire is designed to determine your language background

PART 1: Language Profile

Subject number: ____

Age: ________________ Sex: ☐ Female ☐ Male

Country and place of birth: ____________________________________

Years lived in native country (from age ….. to age …..): ______________________

Years lived in foreign country (from age….. to age…..):______________________

If lived in more than one country, please specify (country/ duration):____________

Years of English language education in native country (specify country, total # of years, age): ____________

Type of English language education received (private lessons, school, etc.):_____________

Who taught English? Please specify (native English/ other):___________________

Years and type of English language education in another country (specify country, total # of years, age):

____

Known learning disabilities: ____________________________________

Current occupation:_________________________ level of study:_________________________

Please categorise yourself according to your language skills:

1 ☐ I speak and read only in English.

2 ☐ I speak and read in English and speak / read in one or more second language(s).

3 ☐ I am bilingual; I speak one of my second languages fluently (i.e. I am near-native).

4 ☐ I am bilingual; I learned two languages simultaneously when I was a child.

5 ☐ I am multilingual; I am fluent or near-native in two or more languages and know one or more languages in addition to my fluent ones.

Please fill in the age at which you started to learn, the learning situation (i.e., home, school, extended stay in a foreign country), and the present use for each of the languages you know. For example, you might write "English, birth, home, now everyday use" or for a second or further language, "French, 12, school, spoken at school/university."

Language: Age: Learning Situation: Present Use:

Native Language:

____

Second Language (or if bilingual, second fluent language):

____

Other Languages (list in order of fluency):

Language: Age: Learning Situation: Present Use:

____

____

____

____

Language Questionnaire

This questionnaire is designed to determine your language background

PART 2: Language Exposure & Self-Assessment

1. Please outline extensive stays (longer than two weeks) or times you lived in a country other than the native country. For example, you might write “Spain, 8 months when aged 2-3, Spanish”

Country: Length of stay / age: Language spoken there:

____
____
____
____

Please rate your abilities in your native, second and other languages circling the appropriate number.

1. Reading

1=very difficult to read and understand normal texts (i.e., a newspaper article), 5=very easy to read and understand normal texts

a. English:

*_____*_____*_____*_____*
1 2 3 4 5

b. Second language:

*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________) :

*_____*_____*_____*_____*
1 2 3 4 5

2. Writing

1=very difficult to express ideas correctly in writing, 5=very easy to express ideas in writing

a. English:

*_____*_____*_____*_____*
1 2 3 4 5

b. Second language:

*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________):

*_____*_____*_____*_____*
1 2 3 4 5

3. Listening

1=very difficult to understand normal spoken speech, 5=very easy to understand normal spoken speech

a. English:

*_____*_____*_____*_____*
1 2 3 4 5

b. Second language:

*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________) :

*_____*_____*_____*_____*
1 2 3 4 5

4. Speaking
1=very difficult to formulate and verbalize natural-sounding sentences in conversation, 5=very easy to formulate and verbalize fluent sentences in conversation

a. English:
*_____*_____*_____*_____*
1 2 3 4 5

b. Second language:
*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________) :
*_____*_____*_____*_____*
1 2 3 4 5

5. Grammar
1=very difficult to understand how a sentence is put together, 5=very easy to form and understand the structure of sentences in any situation

a. English:
*_____*_____*_____*_____*
1 2 3 4 5

b. Second language:
*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________) :
*_____*_____*_____*_____*
1 2 3 4 5

6. Language Independence
1=When I use this language, I always have to translate from my native language, 5=I feel totally independent in this language and can “think” in it.

a. English:
*_____*_____*_____*_____*
1 2 3 4 5

b. Second language:
*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________) :
*_____*_____*_____*_____*
1 2 3 4 5

Language Preferences & Experience

1. Native language or fluent language 1: _______*English*_______
Second language or fluent language 2: ____________________
Other language (please specify): __________________________

2. Which language do you use most in daily life?

☐ native language ☐ second language

Which language did you learn when you first learned to speak?

☐ native language ☐ second language ☐ both at the same time

☐ other situation (describe ______________________________________)

3. Native language of both parents and language spoken with that parent:

native language: language spoken:

Mother____
Father____

4. *If* you indicated that you acquired two languages during childhood, briefly describe the circumstances.

____

5. What language(s) do you speak at home or extensively with family or friends? With whom you speak the language?

Example: At home: English, with parents
With friends: French, at university

Language spoken at home: With whom:

____
____

Language spoken with friends: With whom:

____
____

6. In which setting is your native language most used?

☐ home ☐ surroundings/work ☐ both equally ☐ other (specify _______________)

7. Your second language?

☐ home ☐ surroundings/work ☐ both equally ☐ other (specify _______________)

8. What percentage of the day is each language used (spoken, reading, writing, thinking)?
Native language ________ Second language ___________ Other language_________________

9. Which language do you prefer to:

Speak in?

☐ native language ☐ second language ☐ other

Listen to?

☐ native language ☐ second language ☐ other

Read in?

☐ native language ☐ second language ☐ other

Write in?

☐ native language ☐ second language ☐ other

10. Regarding each language, at which age did you begin to (for your native language, just fill in a "0" if you acquired the language normally as a child):

Speak?
native language _______ second language _______ other _______

Understand spoken sentences?
native language _______ second language _______ other _______

Read?
native language _______ second language _______ other _______

Write?
native language _______ second language _______ other _______

11. How often do you switch from your native to second language, or visa versa?

1=Never switch languages, 5= Switch languages very frequently

*_____*_____*_____*_____*
1 2 3 4 5

12. How easy is it for you child to switch from your native to second language, or visa versa?
1=very difficult to switch, 5=very easy to switch

*_____*_____*_____*_____*
1 2 3 4 5

13. Please add any additional information you feel is important for us to know below.

THANK YOU.

Appendix 4: Language Background Questionnaire for Bilingual Children

Language Questionnaire

This questionnaire is designed to determine your child's language background

PART 1: Language Profile

Subject number: ____

Age: ________________ Sex: ☐ Female ☐ Male

Country and place of birth: ______________________________________

Years child lived in native country (from age ….. to age …..): ______________________

Years child lived in foreign country (from age….. to age…..):________________________

If lived in more than one country, please specify (country/ duration):____________

Years of child's English language education in native country (specify country, total # of years, age): ______

Type of child's English language education received (private lessons, school, etc.):_____________

Who taught English? Please specify (native English/ other):___________________

Years and type of child's English language education in another country (specify country, total # of years, age):

____

Known learning disabilities: ______________________________________

Mother's occupation:_________________________ level of study:____________________________

Father's occupation:__________________________ level of study:____________________________

Please categorise your child according to her/his language skills:

1 ☐ My child speaks and reads only in English.

2 ☐ My child speaks and reads in English and speaks / reads in one or more second language(s).

3 ☐ My child is bilingual; They speak one of their second languages fluently (i.e., They are near-native).

4 ☐ My child is bilingual; They learned two languages simultaneously when they were a child.

5 ☐ My child is multilingual; They are fluent or near-native in two or more languages and know one or more languages in addition to their fluent ones.

Please fill in the age at which your child started to learn, the learning situation (i.e., home, school, extended stay in a foreign country), and the present use for each of the languages they know. For example, you might write "Greek, birth, home, now everyday use" or for a second or further language, "English, 3, moved in foreign country, spoken at school."

Language: Age: Learning Situation: Present Use:

Language 1:

____

Language 2: (or if bilingual, second fluent language):

____

Other Languages (list in order of fluency):

Language: Age: Learning Situation: Present Use:

____

____

____

____

Language Questionnaire
This questionnaire is designed to determine your child's language background

PART 2: Language Exposure & Parent/ guardian's Assessment

1. Please outline extensive stays (longer than two weeks) or times your child lived in a country other than the native country. For example, you might write "Australia, 8 months when aged 2-3, English"

Country: Length of stay / age: Language spoken there:

____
____
____
____

2. Please rate your child's abilities in their language 1 (a), language 2 (b), and other languages (c) circling the appropriate number.

Reading
1=very difficult to read and understand normal texts (i.e., a schoolbook), 5=very easy to read and understand normal texts

a.
*_____*_____*_____*_____*
1 2 3 4 5

b.
*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ____________________):
*_____*_____*_____*_____*
1 2 3 4 5

Writing
1=very difficult to express ideas correctly in writing, 5=very easy to express ideas in writing

a.
*_____*_____*_____*_____*
1 2 3 4 5

b.
*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ____________________):
*_____*_____*_____*_____*
1 2 3 4 5

Listening
1=very difficult to understand normal spoken speech (i.e., the class teacher's instructions at school), 5=very easy to understand normal spoken speech

a.
*_____*_____*_____*_____*
1 2 3 4 5

b.
*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ____________________):
*_____*_____*_____*_____*
1 2 3 4 5

Speaking
1=very difficult to formulate and verbalize natural-sounding sentences in conversation, 5=very easy to formulate and verbalize fluent sentences in conversation

a.
*_____*_____*_____*_____*
1 2 3 4 5

b.
*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________):
*_____*_____*_____*_____*
1 2 3 4 5

Pronunciation
1=My child has a **very** distinct foreign accent when s/he speaks English, 5=People think my child is a native English speaker when they speak

English:
*_____*_____*_____*_____*
1 2 3 4 5

Grammar
1=very difficult to understand how a sentence is put together, 5=very easy to form and understand the structure of sentences in any situation

a.
*_____*_____*_____*_____*
1 2 3 4 5

b.
*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________):
*_____*_____*_____*_____*
1 2 3 4 5

Language Independence
1=When my child uses this language, they always have to translate from their language1, 5=my child feels totally independent in this language and can "think" in it.

a.
*_____*_____*_____*_____*
1 2 3 4 5

b.
*_____*_____*_____*_____*
1 2 3 4 5

c. Other language (specify which ______________________):
*_____*_____*_____*_____*
1 2 3 4 5

Language Preferences & Experience

1. Native language or fluent language 1: ______________
Second language or fluent language 2: _____________
Other language (please specify): ___________________________

2. Which language does your child use most in daily life?

☐ language 1 ☐ language 2

Which language did your child learn when they first learned to speak?

☐ language 1 ☐ language 2 ☐ both at the same time

☐ other situation (describe _______________________________________)

3. Native language of each parent and language spoken with that parent:

native language: language spoken:

Mother____

Father____

4. *If* you indicated that your child acquired two languages during childhood, briefly describe the circumstances.

____

5. What language(s) does your child speak at home or extensively with family or friends? With whom do they speak the language?

Example: At home: Greek, with parents
With friends: English, at school

Language spoken at home: With whom:

____

____

Language spoken with friends: With whom:

____

____

6. In which setting is your child's language 1 most used?

☐ home ☐ surroundings/ school ☐ both equally other (specify _______________)

7. Your child's language 2?

☐ home ☐ surroundings/ school ☐ both equally other (specify_______________)

8. What percentage of the day is each language used (spoken, reading, writing, thinking)?
Language 1 ________ Language 2___________ Other language_________________

9. Which language does your child prefer to:

Speak in?

☐ language 1 ☐ language 2 ☐ other

Listen to?

☐ language 1 ☐ language 2 ☐ other

Read in?

☐ language 1 ☐ language 2 ☐ other

Write in?

☐ language 1 ☐ language 2 ☐ other

10. Regarding each language, at which age did your child begin to (Please fill in a "0" if they acquired the language(s) from birth):

Speak?
Language 1_______ Language 2_______ other _______

Understand spoken sentences?
Language 1_______ Language 2_______ other _______

Read?
Language 1_______ Language 2_______ other _______

Write?
Language 1_______ Language 2_______ other _______

11. How often does your child switch from their language 1 to language 2, or visa versa?

1=Never switches languages, 5= Switches languages very frequently

*_____*_____*_____*_____*
1 2 3 4 5

12. How easy is it for your child to switch from their language 1 to language 2, or visa versa?
1=very difficult to switch, 5=very easy to switch

*_____*_____*_____*_____*
1 2 3 4 5

13. Please add any additional information you feel is important for us to know below.

THANK YOU.

Appendix 5: Language Background Questionnaire for Monolingual British English Children

Language Questionnaire

This questionnaire is designed to determine your child's language background

PART 1: Language Profile

Subject number: ______________________________

Age: ____________ Sex: ☐ Female ☐ Male

Country and place of birth: ______________________________

Years child lived in native country (from age ….. to age …..): ____________________

Years child lived in foreign country (from age….. to age…..):____________________

If lived in more than one country, please specify (country/ duration):__________

Years of child's English language education in native country (specify country, total # of years, age): ______

Type of child's English language education received (private lessons, school, etc.):__________

Who taught English? Please specify (native English/ other):______________

Years and type of child's English language education in another country (specify country, total # of years, age):

____

Known learning disabilities: ______________________________

Mother's occupation:____________________ level of study:____________________

Father's occupation:____________________ level of study:____________________

Please categorise your child according to her/his language skills:

1 ☐ My child speaks and reads only in English.

2 ☐ My child speaks and reads in English and speaks / reads in one or more second language(s).

3 ☐ My child is bilingual; They speak one of their second languages fluently (i.e., They are near-native).

4 ☐ My child is bilingual; They learned two languages simultaneously when they were a child.

5 ☐ My child is multilingual; They are fluent or near-native in two or more languages and know one or more languages in addition to their fluent ones.

Please fill in the age at which your child started to learn, the learning situation (i.e., home, school, extended stay in a foreign country), and the present use for each of the languages they know. For example, you might write "Greek, birth, home, now everyday use" or for a second or further language, "English, 3, moved in foreign country, spoken at school."

Language: Age: Learning Situation: Present Use:

Language 1:

____

Language 2: (or if bilingual, second fluent language):

____

Other Languages (list in order of fluency):

Language: Age: Learning Situation: Present Use:

____

____

____

____

Language Questionnaire

This questionnaire is designed to determine your child's language background

PART 2: Language Exposure & Parent/ guardian's Assessment

1. Please outline extensive stays (longer than two weeks) or times your child lived in a country other than the native country. For example, you might write "Australia, 8 months when aged 2-3, English"

Country: Length of stay / age: Language spoken there:

____
____
____
____

Please rate your child's abilities in English circling the appropriate number.

1. Reading

1=very difficult to read and understand normal texts (i.e., a schoolbook), 5=very easy to read and understand normal texts

a. English:
*_____*_____*_____*_____*
1 2 3 4 5

2. Writing

1=very difficult to express ideas correctly in writing, 5=very easy to express ideas in writing

a. English:
*_____*_____*_____*_____*
1 2 3 4 5

3. Listening

1=very difficult to understand normal spoken speech (i.e., when the class teacher gives instructions), 5=very easy to understand normal spoken speech

a. English:
*_____*_____*_____*_____*
1 2 3 4 5

4. Speaking

1=very difficult to formulate and verbalize natural-sounding sentences in conversation, 5=very easy to formulate and verbalize fluent sentences in conversation

a. English:
*_____*_____*_____*_____*
1 2 3 4 5

5. Grammar

1=very difficult to understand how a sentence is put together, 5=very easy to form and understand the structure of sentences in any situation

a. English:
*_____*_____*_____*_____*
1 2 3 4 5

Language Preferences & Experience

Native language or fluent language 1: ________*English*_______

Please add any additional information you feel is important for us to know below.

THANK YOU.

Appendix 6: Informed Consent Form for Adults

University of Essex

Form of Consent to take part in a Research Project (CONFIDENTIAL)

Title of project/ Investigation:

Acquisition of the British English sound system by Greek-English bilinguals.

Name of Principal Investigator: Ms Eleni Galata

Brief Outline of Project: This project has two aims: first to explore whether the knowledge of English in native Greek adults who are proficient in English might affect the way they speak in their second language. We will compare their pronunciation to native English speakers. It also aims to explore whether the exposure of Greek-English bilingual children to English from a very early age has any effect on the way they speak English. We will compare their pronounciation to English native speakers.

What does participating involve?

Participation involves taking part in three different tasks: a story reading task, a matching task, and a new story task. Details about each task are provided below.

1. Story task: You will be presented with a story book, which will be read aloud by the researcher. You will be asked to name some pictures in the story, which stand for different words. Your responses will be audio-recorded.

2. Matching task: You will be asked to respond to some pictures on a timed power point presentation, by naming the objects or animals presented. Then, you will be asked to help the researcher by handing out the relevant pictures in the order presented and later tell a story based on the same pictures (new story task). Your responses will be audio-recorded.

If you are willing to participate you will be asked to read through this information sheet, sign the consent form and return it. At that point, your participation can be confirmed and arrangements can be made for the sessions.

The study will take about 1 hour in total and involve the three tasks mentioned above and filling in a brief questionnaire about your language background.

Consent Form

Please tick the appropriate boxes	**Yes**	**No**
Taking Part		
I have read and understood the project information sheet.	☐	☐
I have been given the opportunity to ask questions about the project.	☐	☐
I agree to take part in the project. Taking part in the project will involve participation in the two tasks outlined earlier, while my responses will be audio recorded.	☐	☐

I understand that taking part in the study is entirely voluntary; I can withdraw from the study at any time and I do not have to give any reasons for why I no longer want to take part. ☐ ☐

Use of the information I provide for this project only

I understand that my personal details such as phone number, name and address will not be revealed to people outside the project. ☐ ☐

I understand that the results of this study may be quoted in publications, reports, web pages, and other research outputs, with no link to my or my child's personal details. ☐ ☐

Use of the information I provide beyond this project

I agree for the data I provide to be archived digitally in a personal computer for research purposes only. ☐ ☐

I agree to the submission of the anonymised audio recordings and transcripts to a research archive. I understand that other genuine researchers will have access to this data only if they agree to preserve the confidentiality of the information as requested in this form. I also understand that I can still take part in this project even if I tick the "no" box for this question and do not agree to the submission of the data in a research archive. ☐ ☐

I understand that other genuine researchers may use my results in publications, reports, web pages, and other research outputs, only if they agree to preserve the confidentiality of the information as requested in this form. ☐ ☐

____________________ ____________________ ________

Name of participant [printed] Signature Date

____________________ ____________________ ________

Researcher [printed] Signature Date

Project contact details for further information:

Ms Eleni Galata

PhD Student

Department of Language and Linguistics

University of Essex, Wivenhoe Park

Colchester, CO4 3SQ

Contact telephone number: 07842416858

Email address: egalat@essex.ac.uk

Department of Language and Linguistics, University of Essex, Consent and Ethical Approval

University of Essex

Form of Consent to take part in a Research Project (CONFIDENTIAL)

Title of project/ Investigation:

Acquisition of the British English sound system by Greek-English bilinguals.

Name of Principal Investigator: Ms Eleni Galata

Brief Outline of Project: This project aims to explore whether the exposure of Greek-English bilingual children to English from a very early age has any effect on the way they speak English. We will compare their pronounciation to English native speakers. It also aims to explore to explore whether the knowledge of English in native Greek adults who are proficient in English might affect the way they speak in their second language. We will compare their pronunciation to native English speakers.

What does participating involve?

Participation involves taking part in three different tasks: a story reading task, a matching task, and a new story task. Details about each task are provided below.

1. Story task: The participants will be presented with a story book, which will be read aloud by the researcher. The participants will be asked to name some pictures in the story, which stand for different words. Their responses will be audio-recorded.

2. Matching task: The participants will be asked to respond to some pictures on a timed power point presentation, by naming the objects or animals presented. Then, the participants will be asked to help the researcher by handing out the relevant pictures in the order presented and later tell a story based on the same pictures (new story task). Their responses will be audio-recorded.

If you are willing to let your child participate you will be asked to read through this information sheet, sign the consent form and return it. At that point, your child's participation can be confirmed and arrangements can be made for the sessions.

The study will take about 1 hour in total and involve the two tasks mentioned above and filling in a brief questionnaire about the child's language background.

Consent Form

Please tick the appropriate boxes	Yes	No
Taking Part		
I have read and understood the project information sheet.	☐	☐
I have been given the opportunity to ask questions about the project.	☐	☐
I agree to let my child take part in the project. Taking part in the project will involve participation in the two tasks outlined earlier, while my child will be audio recorded.	☐	☐
I understand that taking part in the study is entirely voluntary; I can withdraw my child from the study at any time, and I do not have to give any reasons for why I no longer want my child to take part.	☐	☐

Use of the information I provide for this project only

I understand that my personal or my child's details such as phone number, name and address will not be revealed to people outside the project. ☐ ☐

I understand that the results of this study may be quoted in publications, reports, web pages, and other research outputs, with no link to my or my child's personal details. ☐ ☐

Use of the information I provide beyond this project

I agree for the data I provide to be archived digitally in a personal computer for research purposes only. ☐ ☐

I agree to the submission of the anonymised audio recordings and transcripts to a research archive, such as the CHILDES (Child Language Data Exchange System; http://childes.psy.cmu.edu/). I understand that other genuine researchers will have access to this data only if they agree to preserve the confidentiality of the information as requested in this form. I also understand that I can still take part in this project even if I tick the "no" box for this question and do not agree to the submission of the data in a research archive. ☐ ☐

I understand that other genuine researchers may use my results in publications, reports, web pages, and other research outputs, only if they agree to preserve the confidentiality of the information as requested in this form. ☐ ☐

__________________________ _______________________ _________

Name of participant's parent/carer [printed] Signature Date

____________________________ _________________________ __________

Researcher [printed] Signature Date

Project contact details for further information:

Ms Eleni Galata

PhD Student

Department of Language and Linguistics

University of Essex, Wivenhoe Park

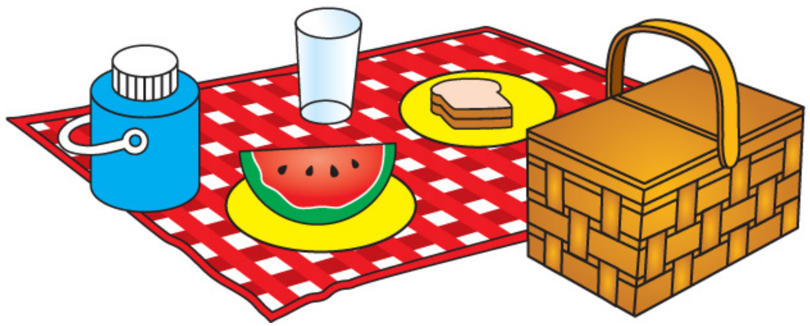
Colchester, CO4 3SQ

Contact telephone number: 07842416858

Email address: egalat@essex.ac.uk

Appendix 8: Story Book Task (Task 1)

The animals are going on a picnic!

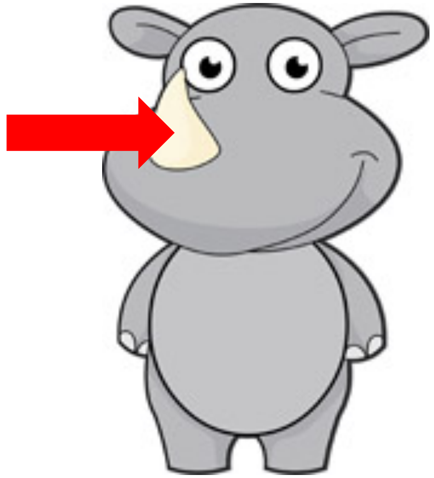


It was a very  day, so the animals decided to go on a picnic.

Many animals wanted to go to the picnic.

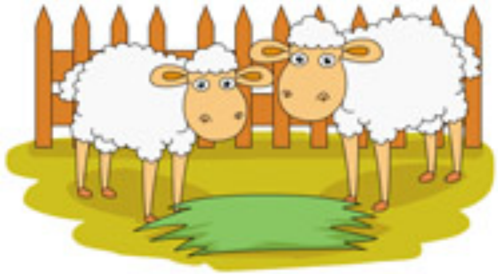
Oh look!

Here comes a  !

And he has a huge  on his nose!

Who comes behind him?

Oh, there is a whole herd of

 !

What is this sheep wearing?

Is he wearing a jacket?

Or maybe he's wearing a sweater?

No! He's wearing a 

with a  !

And the other one is wearing a

and he looks so funny

with this  on his head!

Look! Look! There is also an owl at the picnic!

She wears a  on her left !

Who does she have with her?

Oh yes! There's a little bee!

What is she carrying?

I think she's carrying a huge

bucket of  !

"Can we have some honey for tea?" asked one of the sheep.

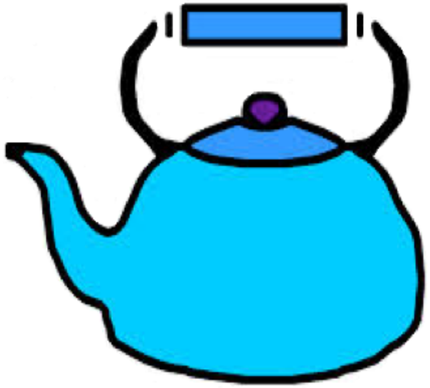
"Yes!" said everyone.

"But how are we going to make tea?" cried the hippo.

“Look! Look! The  is going to help us!”

“How?” asked the rest.

“I’m going to get the , and the mugs, and the teabags ready” said the owl, “and the mouse can put the

 on“.

“And who else is coming?“

“Is that a chicken?”

“No!”

“It looks like a  !”

"And there is also a little dog,

who likes to sleep

in his  all day!

All the animals were very happy!

They were so happy that they started singing and dancing.

One of the cows started

dancing with a hula  and the rabbits started stomping

their  .

“What should we do next?” asked the cows.

“We already have some food, but I’d like some dessert too!”, said the owl.

"Let's go to the  and buy some sweets for our picnic".

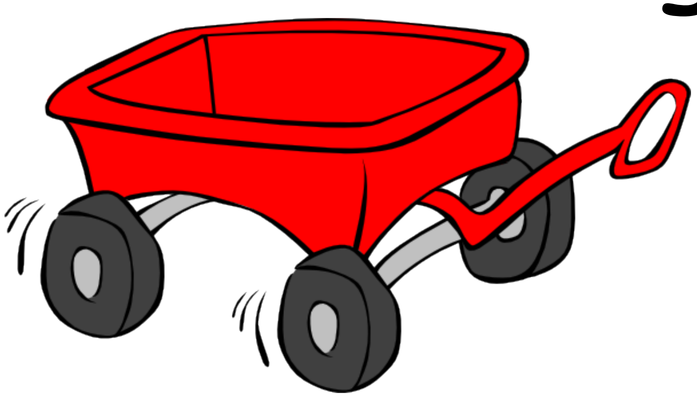
“But how are we going to carry all our food?” asked one of the pigs.

“Should we get a trolley?”

“Maybe we should ask our

friend the  to help us!

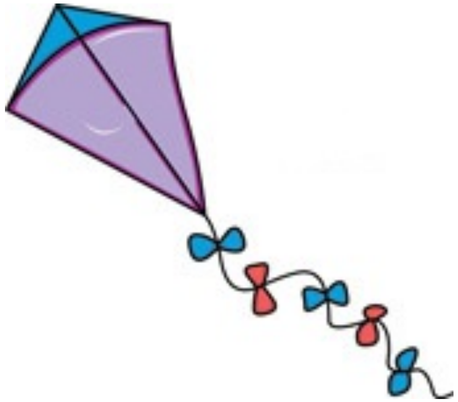
He's strong enough to pull a

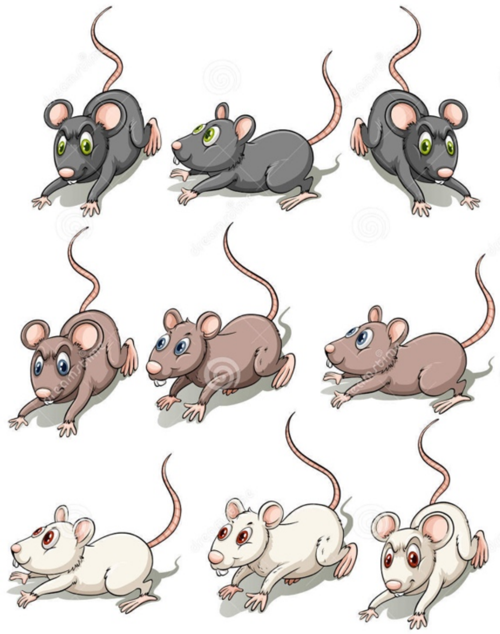


."

"How are we going to spend our day at the picnic?" asked a rabbit.

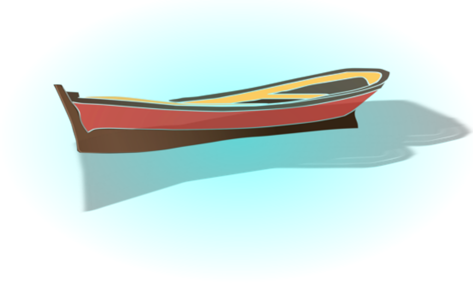
“We could  some flowers” replied one of the sheep,

“or even fly a !”

“Or chase some  !”

said the  greedily.

Then someone said: "Why don't

we go for a trip on a  ?"

"There are too many of us" explained the wise owl.

“Maybe we should look for something larger.

I think we should travel on this huge !”

“Hey! Everyone look at its sails! They have a  on them!“

“That’s a great way to travel!“

“I think we’ll all have fun!” shouted all at the same time.

“Yes, but we should not be tired before our trip!”

“I think we should go and sleep

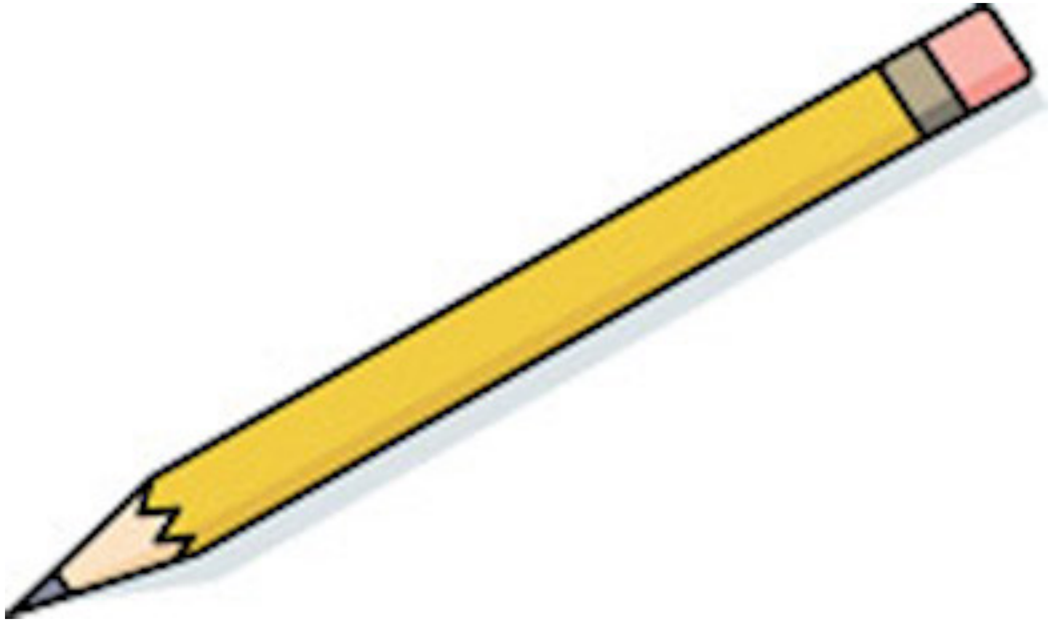
in our  tonight and get some rest!”

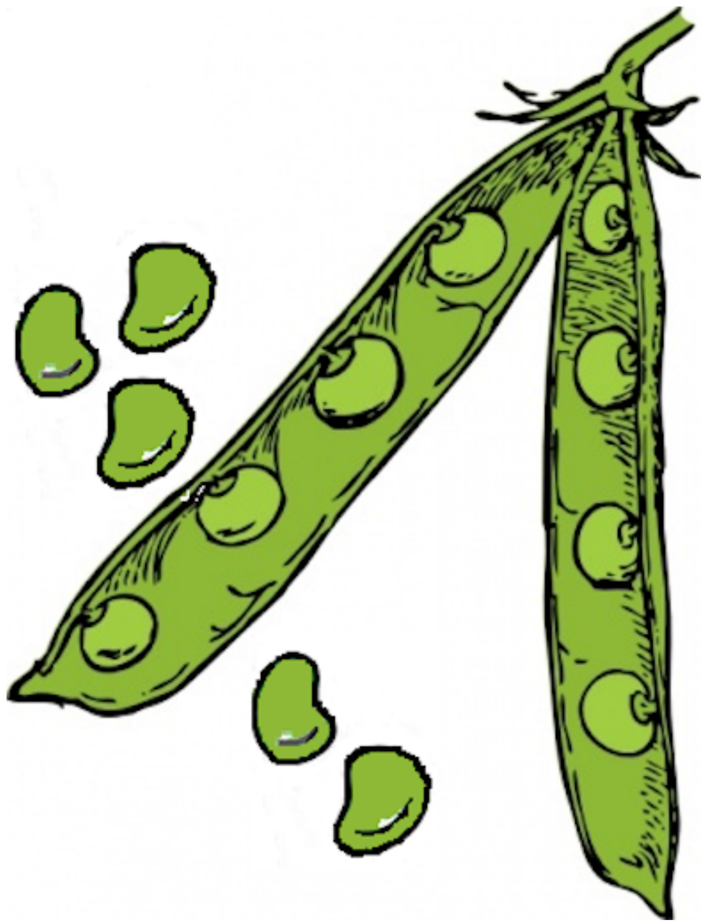
“That’s a great idea!

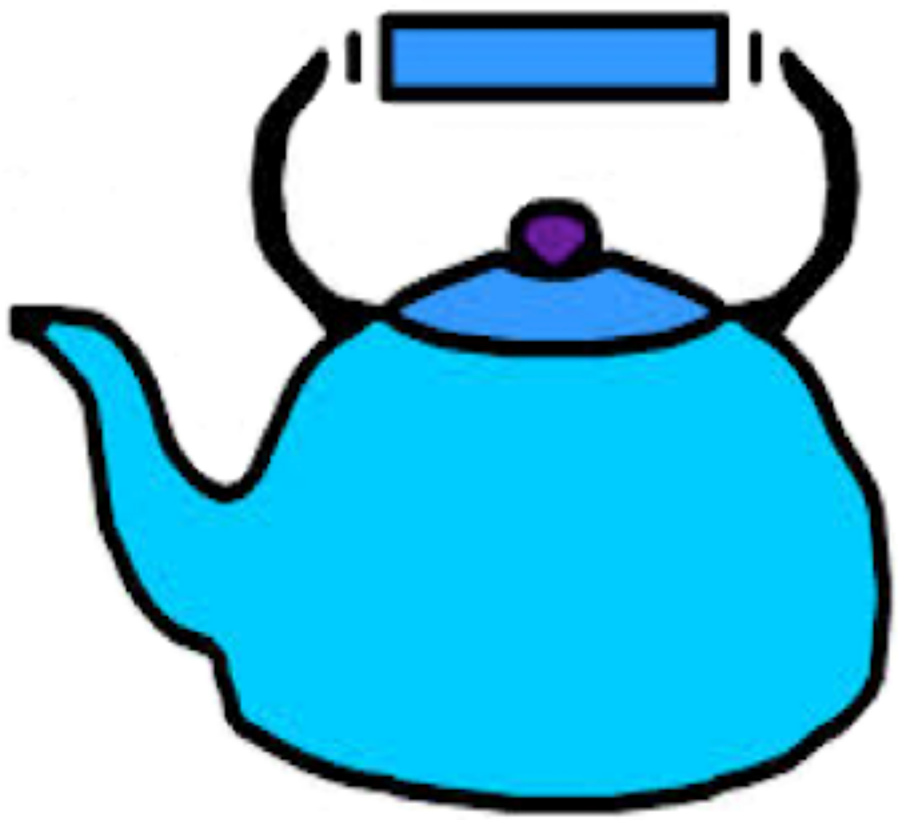
Let's  hands and promise to meet everyone tomorrow."

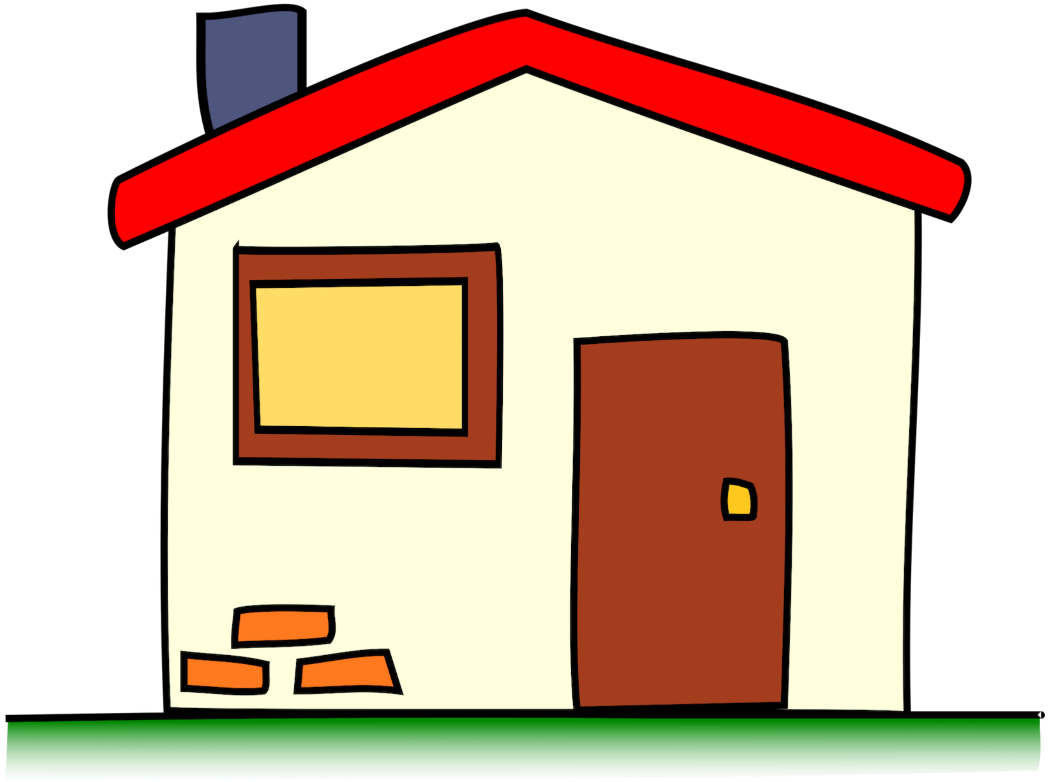
"It will be an amazing adventure, you'll see!"

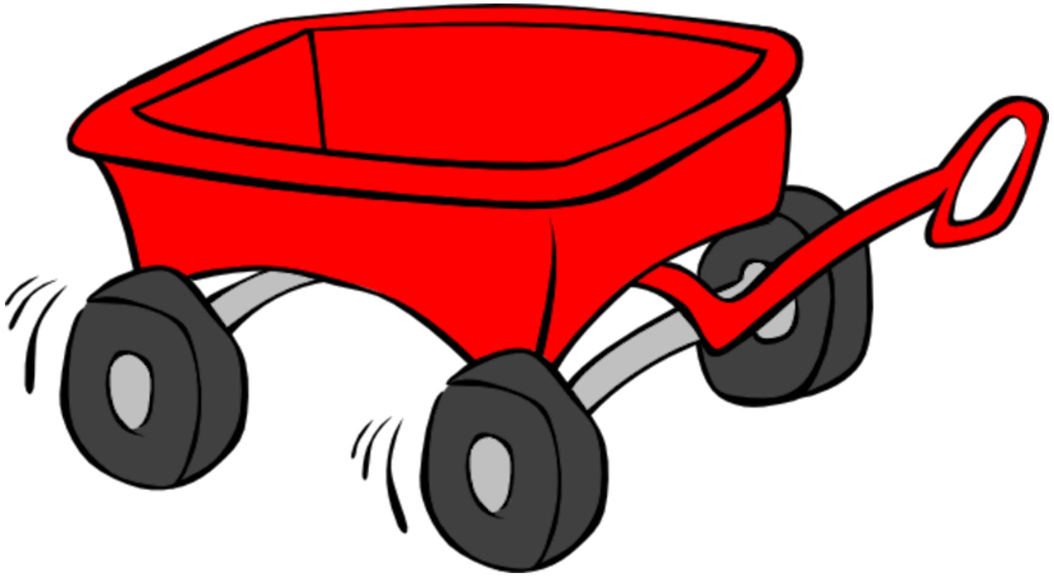
<u>Appendix 9: Pictures Used in the Matching and New Story Tasks (Tasks 2 & 3)</u>

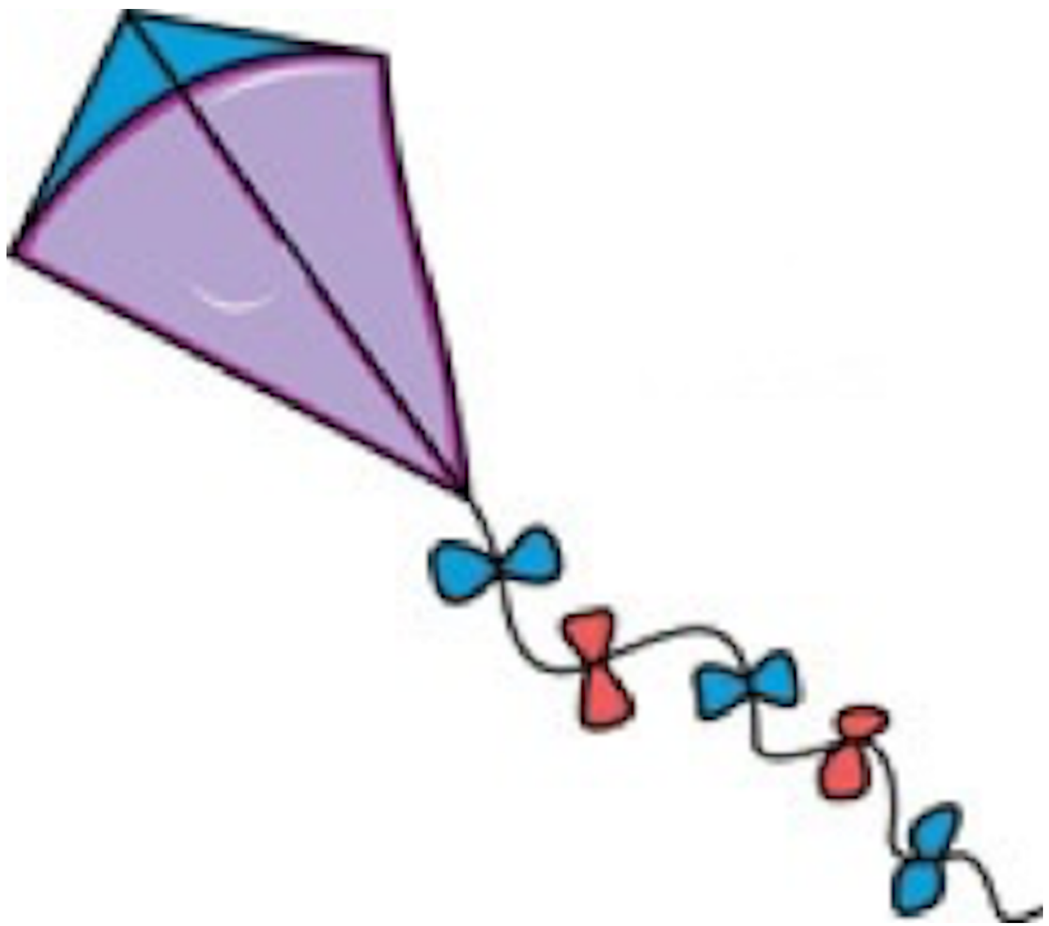


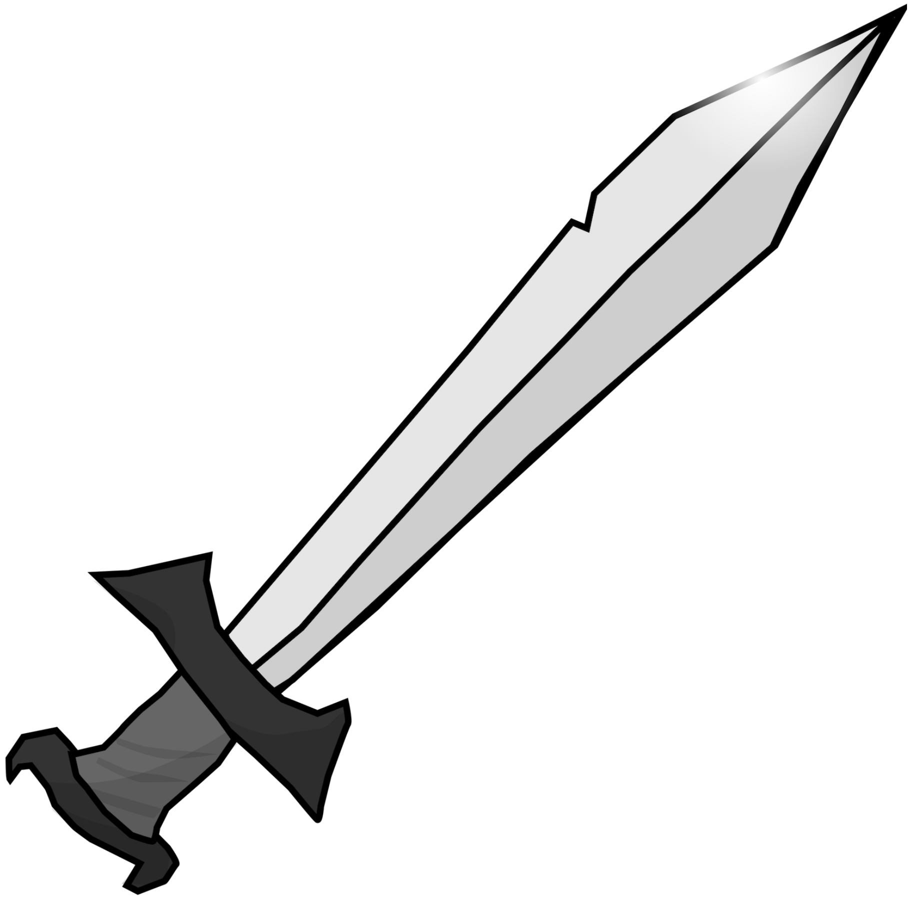


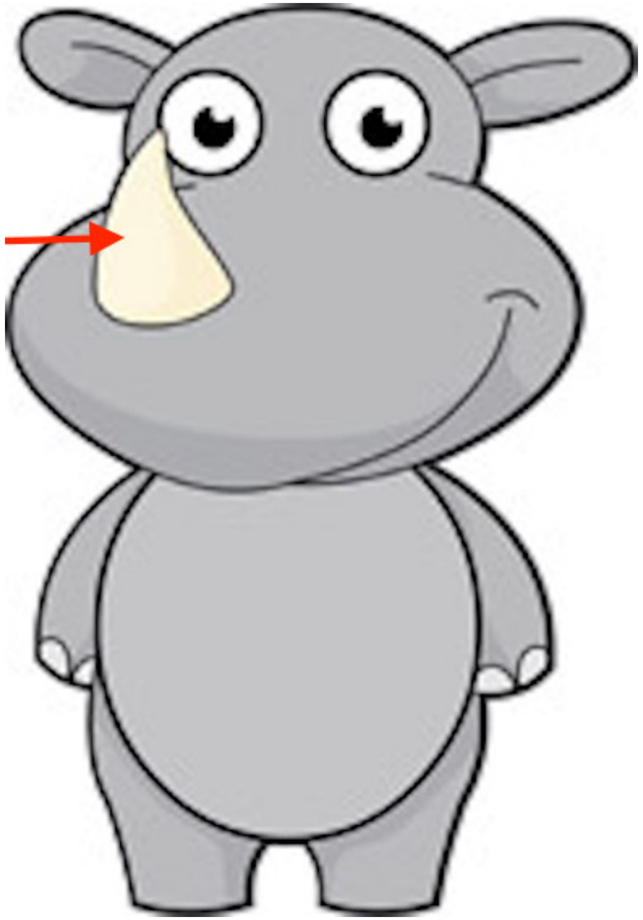


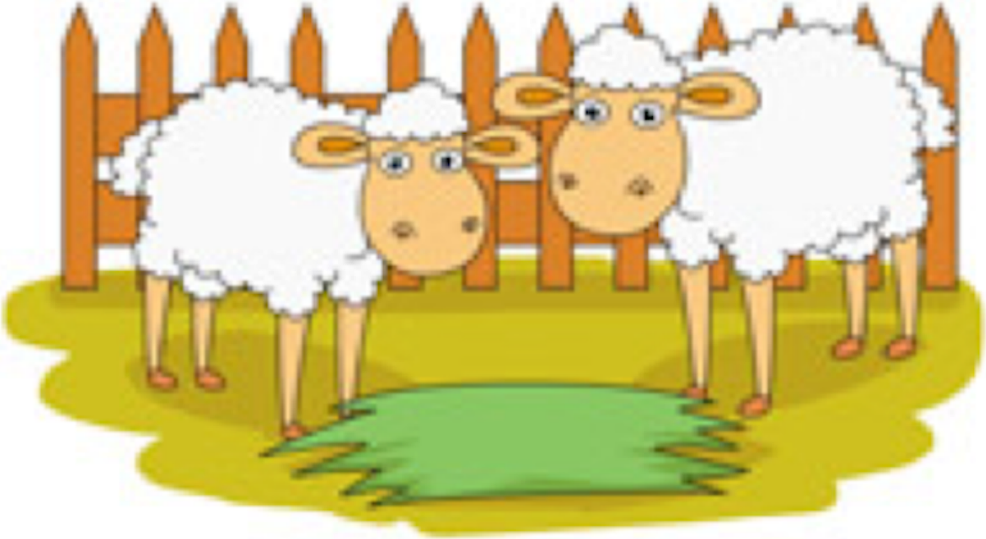


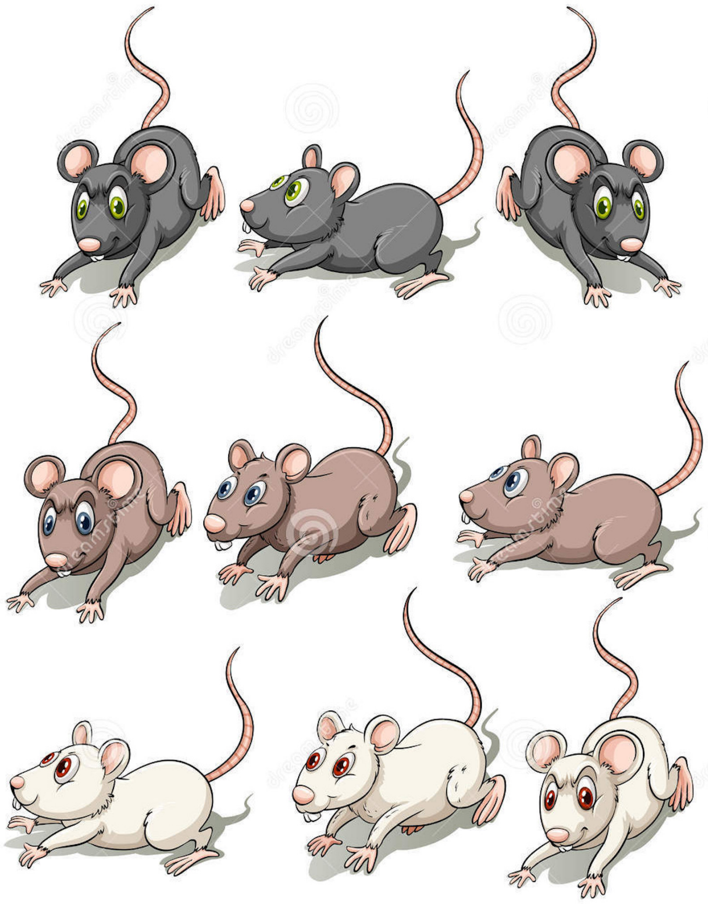


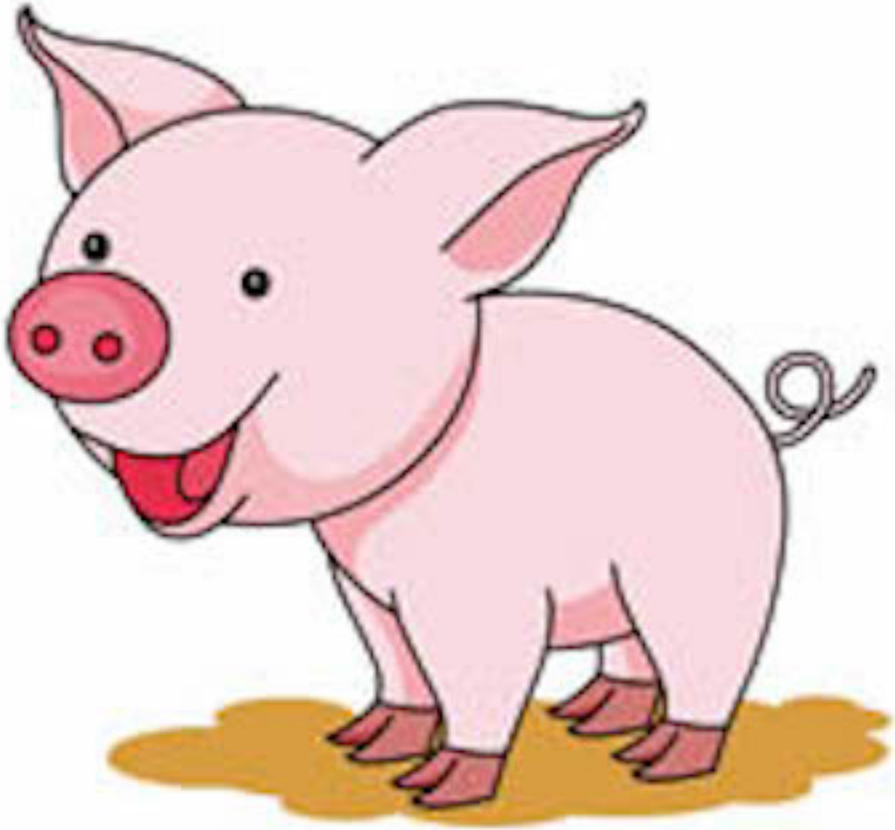


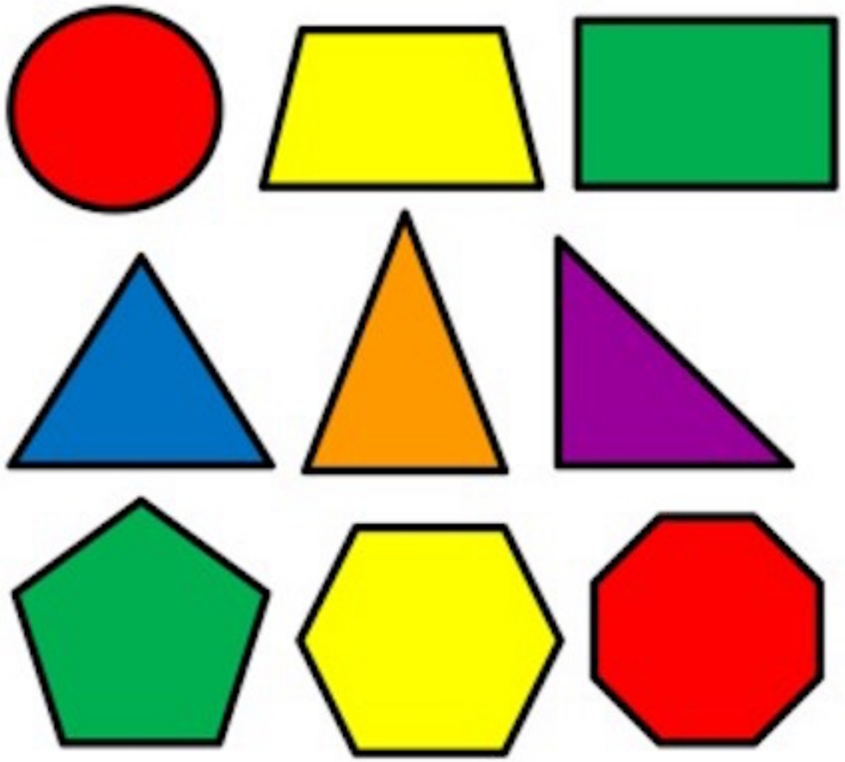












Appendix 10: Participant Recruitment Flyer

Native English and/or Greek-English bilinguals wanted for research project

- Is your child aged between 4 and 10?
- Is she/he a native English speaker or a Greek-English bilingual?
- Are you interested in helping in an exciting research project assessing English pronunciation?
- We will be having fun, playing with different language games such as pictures and a story book!

For more info, please get in touch or sign up now!

Lenia Galata
PhD Student
Department of Language and Linguistics
University of Essex

egalat@essex.ac.uk
07842416858
https://www.essex.ac.uk/langling/staff/profile.aspx?ID=3614

The animals are going on a picnic!