An analysis of /r/ variation in Singapore English

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This dissertation is submitted for

the degree of

Doctor of Philosophy

Theoretical and Applied Linguistics

Modern and Medieval Languages

University of Cambridge

September 2017

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In modern urban Singapore, the variety of English spoken evolves through a continual negotiation of adhering to traditionally standard models and creating local norms in the environment of myriad social and substratum language influences. Singapore English (SgE) speakers constantly navigate a multilingual situation which requires them to simultaneously handle the language systems of the society's main working language, English, and at least one other language while being immersed in a linguistic environment where interactions in countless other languages and varieties take place. Variation, thus, inevitably exists within SgE as depicted in models of variation developed throughout the years. While this variation manifests itself in many forms, this study focuses particularly on the sociophonetic variation of /r/ realisations, an area of SgE in which the little research done previously provides only impressionistic or preliminary descriptions.

Here, /r/ variation is studied through an auditory and acoustic investigation of both read and conversational speech data collected from male and female SgE speakers of Singapore's major ethnic groups (i.e. Chinese, Malay, Indian, and Eurasian). Through the use of an auditory perceptual strength index and a combination of fixed- and mixed- effects statistical modelling methods, this study reveals /r/ variation in SgE on several levels. Results show that SgE speakers produce a range of /r/ variants, both within and between speakers, and also highlight the intertwined roles of language-internal factors (e.g. phonological contexts, word class) and language-external factors (e.g. speech style, ethnicity, speaker sex) in determining variation in both the realisation and distribution of /r/ in SgE. Finer auditory and acoustic distinctions are found in approximant /r/, reflecting both the phonetic complexity of /r/ and the multifaceted nature of SgE. Additionally, supportive evidence for the presence of innovative trends in SgE /r/ realisation (i.e. labiodental /r/) and of fading ones (i.e. taps/trills) is also found.

Taken together, these results provide the basis for discussions of a potential situation of natural /r/-weakening and the impacts of speech styles, cross-linguistic influences, and language dominance on /r/ variation. They also postulate trends of change in /r/ realisations in SgE affected by age, ethnicity and speaker sex. Besides contributing to the general on-going discussions of synchronic variation and diachronic change in the story of /r/, this study shares insights into the intricacies of studying linguistic patterns in multilingual urban communities and provides empirical evidence for the need of a multidimensional approach in researching multicultural varieties and/or 'New Englishes' like SgE.

Author's Declaration

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Preface and specified in the text.

It is not substantially the same as any that I have submitted, or, is being concurrently submitted for a degree or diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text. I further state that no substantial part of my dissertation has already been submitted, or, is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text

It does not exceed the prescribed word limit for the Modern and Medieval Languages Degree Committee.

Acknowledgements

As I write these very ‘last pages’ of my PhD thesis, I am filled with a whole lot of indescribable emotions – something that I’ve come to learn to accept in the course of the PhD. I have gained so much in the past four years, much more than I had ever expected. The completion of this PhD thesis, and my survival through the toughest times, would not have been possible if not for the people I’ve met in (and through) my time at Cambridge and also everyone back home in Singapore. All of whom have made this otherwise unfathomably challenging journey a precious and enlightening experience that I will always treasure. So, it is with a grateful heart that I make these special mentions.

Prof. Francis Nolan – Thank you, Francis, for being ever knowledgeable and ever supportive. If not for your interest in my proposed topic and being so willing to be a part of my madness of a study, I would not be here today. Thank you for sharing all that knowledge and for also always ‘putting me in a spot’ with difficult questions (Haha), encouraging me to think independently, to question and to explore. Because of this, I have grown. I fully appreciate that you’re always giving of your time and cared not only about my academic soundness but also for my physical well-being and sanity. I really could not have asked for a better supervisor. For the record, I will always miss ‘PhD trainings’.

Prof. Jane Stuart-Smith & Dr. Kirsty McDougall – Thank you so very much for examining my thesis and bearing with my horribly heavy stats chapter. All the useful feedback that you’ve shared has definitely given me direction in my next steps of research and I am excited! Thank you, especially, for your enthusiasm about my work. I cannot express how much this means to me for all that I’ve put in the last four years and also for the academic road ahead. My sincerest thanks!

Assoc. Prof. Angelia Poon, Assoc. Prof. Ramona Tang, Prof. Low Ee Ling, and Prof. Christine Goh, together with the board of deans at the National Institute of Education, Singapore – Thank you for believing in my abilities and in the richness that Phonetics and Phonology brings to our institution. I am immensely grateful for the constant support of the NIE Overseas Graduate Scholarship and of the leaders at the English Language and Literature Academic Group. Thank you for making my pursuing of the PhD at Cambridge possible.

Prof. David Deterding – Though I have not seen you in ages now, your words of encouragement never fail to get me fighting again when I get disheartened. Thank you, for giving me the strong foundations in P&P, for getting me started on this exciting '/r/ business', for believing in me, and for being such an inspiration.

The participants of my study – every single one of you were so willing spend so much more of the designated recording time with me just chatting about my work and what it means to me and to Singapore English. You have been a great source of motivation and have reassured me that what I'm doing is all worthwhile. Without you, there won't be this study. Thank you!

My phon lab peeps – Thanks for all the Tuesdays in the lab and at the Granta! It would not have been the same without you. Special shout-out to Adrian, Anna, Ricky & Yang - You guys are the craziest, weirdest people I have ever met and I have been fortunate to have spent so much time with you! Thank you for the countless snack/tea sessions and the endless chats (both intellectual and absolutely mindless frivolous ones). I am glad I always had you guys around! A doubly special shout-out to Yang – Oh my god! I don't know what I would have done with all my data if not for you. Thank you for being so excited about my crazy data and for spending all that time working out all the technology, the stats, and mind-boggling numbers with me. You really didn't have to, but you did. You're a true friend, Yangster!

The ones who've kept me sane and missing Cambridge so much – Ainul, Jacqui, Louki, Masha, Shobie & Veli. I cannot imagine my days in Camb without you ladies. For all the days and nights, coffees and cakes, cook-ins and meals out, chats and gripes, laughter and tears, thank you for always being there. You've made the really difficult days more bearable and the happy days so much more enjoyable! I am blessed to have met you.

My family, especially my Mum and Dad who have never once questioned my decision of quitting my job and going back to school, yet always silently supporting me throughout the entire journey. Mummy & Daddy, thank you for instilling in me the love for knowledge and for loving me regardless of my achievements. This one's for you!

My hubby, Kevin – Thank you for being my person right from the start of this PhD journey. Thank you for always being my cheerleader, my sounding board, my 'punching bag', my most ardent supporter. Thank you for always being with me although we were miles apart. Thank you for reminding me to enjoy the journey and for celebrating every little one of my successes along the way. I've done it! And a huge reason is because I have you.

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List of Abbreviations and Acronyms

AmE	American English
BrE	British English
BrunE	Brunei English
BrunM	Brunei Malay
COM	Cultural Orientation Model
EE	Estuary English
ESM	English in Singapore and Malaysia
IndE	Indian English
IndonM	Indonesian Malay
ISE	International Singapore English
LME	Linear Mixed-Effects
LSE	Local Singapore English
MalE	Malaysian English
MLR	Multinomial Linear Regression
NZ	New Zealand
REML	Restricted Maximum Likelihood
RP	Received Pronunciation
CSE	Colloquial Singapore English
ScE	Scottish English
SgE	Singapore English
SGEM	Speak Good English Movement
SSE	Singapore Standard English

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Chapter One

Introduction

1.1 Background

1.1.1 Overview of /r/

Approximately 75% of the world's languages 'contain some form of /r/ phoneme' (Maddieson, 1984) and while most of these exist as a single /r/, 18% of them use two or three rhotics contrastively (Lindau, 1985:157). Although not known to be used contrastively, there is a range of /r/ variants in the English language, both within and across varieties. These /r/ variants, which have been collectively labelled as members of the rhotic class, exist as results of different articulatory gestures. They include differences in tongue shape (e.g. degree of retroflexion), places of constriction (e.g. alveolar, uvular), manners of articulation (e.g. degree of airflow restrictions) and involvement of secondary articulations (e.g. laryngeal constriction, pharyngeal modification, lip-rounding). Within this variation lie the challenges of identifying a definite place of articulation for /r/ (Ladefoged, 2005:119) as well as '[imagining] a single articulatory correlate of a rhotic feature' (Lindau, 1985:158).

Notwithstanding opposition and counter-propositions, it is the traditional and most widely accepted view that the original realisation of /r/ is the alveolar trill [r], 'or at least an apical sound', while all other 'non-trill articulations' are subsequent manifestations caused by various factors (e.g. vocalisation, weakening, innovation) (Bisiada, 2009). Today, the post-alveolar approximant [ɹ] has been established as the most common allophone of British English /r/ (Cruttenden, 2008:220; Wells, 1982:75) and is even stated as the variant used in Received Pronunciation (RP), traditionally being the recommended variant for foreign learners of English (Cruttenden, 2001:209; Roach, 2000:62). For this variant, a lowered third formant (F3), which is caused by pharyngeal and/or post-alveolar constrictions (Stevens, 1998), has been reflected as the most 'distinctive spectral property' (Hayward, 2000:203) and has therefore been the acoustic cue commonly relied on in the identification and analyses of rhotics in English (Kent & Read, 1992; Ladefoged, 2001; Lehiste, 1964; Lindau, 1978;

McGovern & Strange, 1977). This, however, has been acknowledged to not always be ideal as different articulatory gestures for different /r/ variants are characterised by different acoustic features; for example, phases of articulatory closure for trills/taps are signalled by periods of no spectral activity (Ladefoged & Maddieson, 1996), or high F3 but lowered second formant (F2) reflect less tongue retroflexion/retraction and more lip-rounding for labial variants of /r/ (Dalcher, Knight, & Jones, 2008). Other studies on rhotics have also suggested the lowering of the fourth formant (F4) and slight rising of the fifth formant (F5) for retroflex /r/ (Zhou et al., 2008), and a close distance between F2 and F3 as salient acoustic cues for post-alveolar approximant [ɹ] (Knight, Dalcher, & Jones, 2007). There is, thus, a widespread understanding that /r/ has more phonetic variants than any other consonant in the English language (Cruttenden, 2001:207). Additionally, with the spread of English around the world, there is an increased diversity in the profiles of its speakers and in the language environments in which it is spoken. Therefore, an increase in possible phonetic variations in the various allophones can be expected. Consequently, even in the discussion of solely English /r/, it may not always be 'a profitable task' to correlate the presence of the /r/ with a single phonetic property like a lowered F3 (Lindau, 1985:167). The existing phonetic descriptions and symbols used to categorise these rhotics may also prove to not be entirely accurate, as suggested by Kwek (2012), Scobbie (2006) and Whitley (2003).

It is also well-known that /r/ does not only have 'considerable differences in its articulation but [also in] its distribution' (Roach, 2000:62). Variation in English /r/ articulation and distribution in rhotic and non-rhotic varieties of English has long been a popular area of research in sociolinguistic/sociophonetic studies (e.g. Kirkham, 2016; Labov, 1997; Stuart-Smith, 2003, 2007). As Scobbie (2006:337) states so fittingly,

> *'Whatever the case, there should be clearly a special interest in the sociolinguistic systemization of those sounds that are so unusually prone to variation that it is difficult to capture them within a simple articulatory and acoustic definition. Such is the case with the sociolinguistic variable [R].'*

Earlier studies of /r/ in Singapore English (SgE) have also been sociolinguistic in nature and focused mainly on the postvocalic /r/ (e.g. Deterding, 2007; Lim, 2004; Low & Brown, 2005; Poedjosoedarmo, 2000a, 2000b; Tan & Gupta, 1992). Presence of the postvocalic /r/ in SgE, a variety known traditionally to be non-rhotic, has been reported and hypothesised as an occurrence due to cross-varietal influences of American English (AmE) (Poedjosoedarmo, 2000a, 2000b; Tan & Gupta, 1992). More recently, it has been reported to serve as an index for various social factors and is treated in high regard (Tan, 2012). The related phenomena of linking /r/ and intrusive /r/ have also been posited as different systems in SgE by Tan (2012); however, details were not provided given that the study focused on attitudinal perceptions. The only other sociophonetic studies of /r/ in SgE investigated the labiodental approximant [ʋ] in ethnically Chinese SgE speakers (Deterding, 2007; Kwek, 2005, 2012). They suggest that the labiodental [ʋ] is an emerging feature in the speech of young SgE speakers and provide evidence that this labial variant of /r/ in SgE is not only auditorily but also acoustically distinguishable from the usual post-alveolar approximant [ɹ]. The findings of these preliminary studies highlight the presence of /r/ variations in a progressing English variety like SgE, which can be posited as a reliable representative of developments in other varieties with similar linguistic environments and/or are in similar stages of language development. This, thus, sets the stage for the current study which aims to further enhance the existing knowledge and understanding of segmental variation; in this case, of /r/, and highlight the intricacies of considering variation in multicultural urban varieties of English.

1.1.2 Linguistic environment of Singapore

Singapore is a city-state with a population of 5.61 million, as of June 2016. There is a non-resident population of 1.67 million and 3.93 million are residents in the following ethnic composition: 74.3% Chinese, 13.4% Malays, 9.1% Indians and 3.2% others (Singapore Department of Statistics, 2016). With this demography, the language environment in Singapore, understandably, exists as a conglomeration of languages characteristic of speakers from different backgrounds and cultures, held together by the use of a shared language, English.

The introduction of the English language to Singapore dates back to the founding of modern Singapore in 1819 by Sir Stamford Raffles. Before it was attained as a British settlement, Singapore existed as 'Temasek', a tiny island village with about a thousand inhabitants consisting of families of the indigenous Orang Laut (Malay for 'sea people'), Muslim-Malay fisherfolk led by the Temenggong of Johore, and a small number of Chinese cultivators of pepper and gambier (Bloom, 1986; Lim, 2010a); the first two groups, although known to be originally culturally distinct, have long been assimilated into a single community with common cultural and religious practices, and are collectively referred to as Malays (Ali, 2002). Ways of life and the number and profile of inhabitants changed drastically with the arrival of the British who, through the British East India Company, made Singapore a free port. Trading and job opportunities saw Singapore experiencing an influx of Chinese, Malay, Indian and Arab merchants, traders and settlers right from those early years. There was also a significant emigration of British people to Singapore, comprising mainly merchants, administrative personnel and their families, and missionaries. With the arrival of these early immigrants, Singapore developed into a bustling island of different cultures and languages. The population of Singapore continued to increase during the subsequent era of British colonisation (late 1800s – mid 1900s) and by 1939, a few years before the devastation of World War II, it stood at 550,000 inhabitants (Doraisamy, 1969:38 in Lim, 2010b) of which 75% were Chinese, 12% were Malay, 9% were Indian and 4% were Others (e.g. Eurasians, Europeans, Arabs) (Kwok, 2000 in Lim, 2010b). Relative stability in this ethnic proportion has since been seen throughout the continued growth in Singapore's population over the years.

The spread of English, as most scholars argue, was 'exclusively through schools' (Bloom, 1986 crediting Platt & Weber, 1980 in Lim, 2012). At the same time, one would imagine a natural rise in the need for a language of communication with the administrative powers of that time and amongst a multilingual gathering of people especially in more formal contexts. English, with its hegemonic status, thus became the obvious choice, leading to the natural development of an 'out-of-school' form of English. In all other contexts, however, Singaporeans continued to use the languages of their own communities and communicated with others in a situation of code-mixing or by using 'Bazaar Melayu (a pidgin form of Malay) as a lingua franca' (Leimgruber, 2013:9). Although this sets the fundamental picture of the beginnings of the English language in Singapore, the role of education and language policies in post-independent Singapore needs to be highlighted to fully understand the extent of the spread of the English language and how Singapore's current linguistic environment came to be.

Before World War II, Singapore's education system was a divisive one where children could be sent to Chinese-, English-, Malay-, or Tamil-medium schools. Of the approximately 0.5 million inhabitants in 1939, 72,000 were school-going children – 38,000 were enrolled in Chinese-, 27,000 in English-, 6000 in Malay-, and 1000 in Tamil-medium schools (Doraisamy, 1969:38 in Lim, 2010b). At this point, many non-English medium schools had started teaching English as a subject, something which was unheard of pre-1920s (Lim, 2010a). The demand for an English-medium education in Singapore rose steadily and by 1960, the intake for English-medium primary schools was higher than that of Chinese-medium ones (Doraisamy, 1969 in Lim, 2010a).

The first policy which had a direct impact on the status of the English language in Singapore was the advocacy of a bilingual education system in Singapore's 1956 White Paper on education (Lim, 2012) which stipulated the compulsory teaching of English in schools, either as a first language or a second in the Chinese-, Malay-, and Tamil-medium schools. The impetus for this pivotal bilingual education policy was one of 'pragmatic multilingualism' (Kuo & Jernudd, 1994); 'English [to serve] as the language for international trade and business' while Malay, Mandarin and Tamil as vehicles for connections to ethnic roots and cultural traditions (Low, 2012). This was followed by English being officially implemented as the main medium of instruction in education for all Singaporean children from the beginning of primary school in 1987 (Gopinathan, 1994). This meant that all subjects were taught in English and that English was the working language in official school-related communications. Since the bilingual education policy was passed, all students had to learn English as their first language and a pre-assigned second language (i.e. Mother Tongue). This second language was determined by the ethnicity of the students which, in turn, was determined by their father's ethnicity (i.e. Mandarin for the Chinese, Malay for the Malays and Tamil, Hindi, Gujarati, Punjabi, etc. for the Indians). However, the guidelines have changed and it is now possible for students to choose a second language of another ethnic group when starting at the primary school level, and at higher levels of education, there are options for students who express interest in learning a third language. According to Low (2012), the introduction of this bilingual policy laid the foundations for the formation of a generation of what Pakir (1991:174) refers to as ‘English-knowing bilinguals’ who speak English and ‘minimally, their ethnically-ascribed mother tongue’.

Although Singapore has four official languages, English, Malay, Mandarin, and Tamil, as the constitution written in 1963 states, the dominant status of English as the nation’s working language is evident (Leimgruber, 2013). Today, English serves not only as the language of administration and education, but also of law and the media. Malay, Mandarin and Tamil play more of the role of mother tongue languages which are used more frequently, if at all, in informal social contexts.

Besides sharing co-official language status, Malay also remains as the national language due to its historical roots (Low, 2012). It should be noted, however, that although the Malay language (i.e. Bahasa Melayu) has come to be the unifying language of all Singaporeans broadly categorized as ‘Malays’, it was not the language of the ancestors of a significant number of them. Many Singaporeans who are in this general ‘Malay’ ethnic group category have, more specifically, Indonesian ancestry particularly from the regions of Java, Sumatra, Sulawesi and Bawean (Lim, 2010a). However, these Indonesian languages are now spoken only by some older Singaporean Malays who are usually either first generation migrants or still in contact with relatives in their Indonesian ancestral hometowns. Most of their children and grandchildren who are currently either school-goers or part of the Singaporean workforce no longer have/feel any connections to these languages and might not even have perceptual understanding of them. The only connections to their Indonesian heritage are likely to be cooking styles and wedding practices. Thus, despite ancestral differences, the majority of this group of Singaporean Malays readily views the Malay language as their mother tongue. Besides Bahasa Melayu, there is also another contact variety, Baba Malay, spoken by a group of ethnically-mixed Singaporeans called the ‘Peranakans’ or ‘Straits Chinese’ or ‘Baba Chinese’ who are descendants of Chinese men (typically Hokkien, from the Southern-Chinese province of Fujian) and Malay women (Ansaldo & Matthews, 1999; Gupta, 1994). This variety, which is a ‘Hokkien-based, Malay-lexifier pidgin’ (Lim, 1975 in Ho & Platt, 1993), also has a rapid decline of speakers in Singapore. While older generation Singaporean Peranakans still have working knowledge of Baba Malay, many of the younger generation Singaporean Peranakans do not as the majority of their families had slowly replaced it with English as the home language over the years. Although they are categorised as ethnically Chinese, many of the older generation Peranakans do not speak Mandarin. It was common for them to have attended English-medium schools in the early years and had not learnt Mandarin but Malay instead. Furthermore, only English, Baba Malay and Hokkien were spoken in the home environment, resulting in the presence of a 'particular variety' which has influence from Baba Malay, Peranakan English (Lim, 2010b, 2012).

Mandarin has, over the years since Singapore's independence, risen over the other Chinese languages, or 'dialects' as they are termed in Singapore, in terms of spread of usage and prestige. However, it was not the native language of the ancestors of most ethnically Chinese Singaporeans. Early Chinese migrants came mostly from the south of China and spoke languages like Hokkien, Teochew, and Cantonese, as well as, to a lesser extent, Hakka, Shanghainese and Foochow. Although Teochew, Cantonese, and, particularly, Hokkien was used widely, and played important roles in commerce and trade in the early nation-building years of Singapore, they were successfully overshadowed by Mandarin and are now only used in home contexts, if at all. Like in the case of Malay, Mandarin, rather than the languages of their ancestors, has become the language that young Singaporean Chinese identify with in modern Singapore. Many of these young Singaporean Chinese have no working knowledge and proficiency in the languages of their ancestors although they might hear these languages being spoken at home or at the marketplace by the older generation. This is widely known to be a result of language policies and campaigns put forth post-independence as a means to promote Mandarin as the official common binding language for a largely diverse group of ethnically Chinese Singaporeans (Deterding, 2007; Leimgruber, 2013; Lim, 2010a).

It was a different situation with the Indian languages. It appeared to be almost a natural choice for Tamil, being the language of approximately 70% of Singaporean Indians, to be one of Singapore's four official languages. It, however, as stated earlier, coexists with various other Indian languages that arrived in Singapore with early migrants from India, Sri Lanka and Bangladesh. Unlike their Malay and Chinese counterparts, Singaporean Indians do not identify with a common language and have mother tongue languages that are linguistically diverse – for example, Tamil, Telugu, Malayalam, Punjabi, Hindi, Urdu, Sindhi, Gujarati (Leimgruber, 2013; Lim, 2010a; Vaish, Tan, Bokhorst-Heng, Hogan, & Kang, 2010). What all Indian languages have in common, however, is their diminishing value amongst their speakers as compared to English or even Mandarin. Viewed as having little economic value, Indian languages have been replaced with English by many ethnically Indian Singaporeans, particularly the higher class and better educated, in interactions within their communities and homes (Lim, 2010a). It has also become relatively common for ethnically Indian children to take up Mandarin as their second language in school instead of their original mother tongue languages.

From the description given, a general trend of a continually rising status of English in Singapore's society can be seen. However, it is true that this still nestles in an environment surrounded by a whole host of other languages, as seen in Figure 1.1 which shows a breakdown of languages spoken in Singaporean homes. This has various implications on the varieties of English spoken in Singapore which will be covered in the following section.

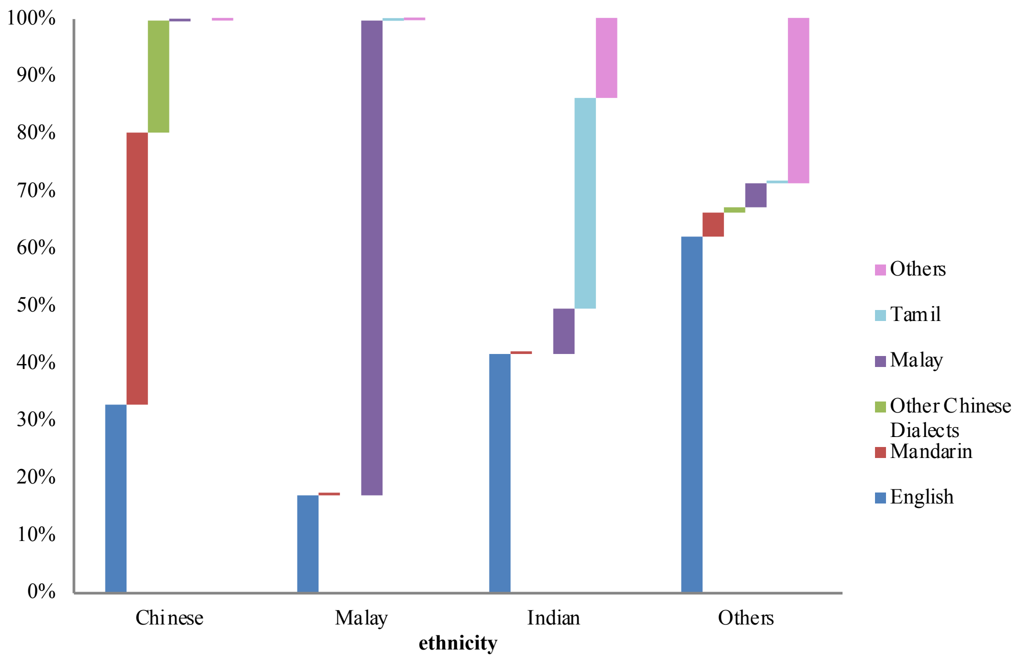

Figure 1.1: Languages frequently spoken at home, according to ethnicity. Information from Singapore Department of Statistics (2010). Ethnicity – 'Others' = Eurasians, Arabs, Japanese, etc. Legend – 'Others' = Other Indian languages, Japanese, etc.

1.1.3 Variation in Singapore English

English, as it was in 19th century Singapore, evolved over the years shaped by its coexistence with the many other languages of migrants who eventually identified themselves as Singaporeans, and with the sociopolitical factors faced by the developing nation. The variety that arose from that has been referred to by scholars, since the late 1980s, as, interchangeably, ‘English in Singapore’ or ‘Singapore English’. It should be noted that this study will also use these two terms somewhat interchangeably when referring to the specific variety of English spoken in Singapore as well as to the general use of the English language in the Singapore society as did Low (2014). They will also be made distinct from ‘English in Singapore and Malaysia’ (ESM); a term which was used in the 1970s to early 1980s, treating the English varieties in Singapore and Malaysia as a single entity (Low, 2014).

It is also necessary to point out that this study focuses on the internationally intelligible SSE variety and not on the colloquial (i.e. Singlish) variety. It is acknowledged, however, that there is also variation within the varieties, as elaborated on in the next paragraphs, and therefore the study is not claiming to focus on a one true ‘undisputed’ SSE variety. It should also be noted that this study is, by no means, identifying and imposing a formal ‘standard’ per se in the use of ‘SSE’ and thus the broader term ‘Singapore English (SgE)’ will be used in this study to refer to the more formal, internationally-intelligible variety that is not Singlish. More details on the profiles of speakers chosen and types of data collected for this variety will be further described in Chapter Three.

Given the history and status of English in Singapore, as well as the existence of a range of languages spoken and their inherent influences on SgE, it is acknowledged that this gives rise to the presence of different varieties of SgE and also the existence of different levels of variation both between and within these varieties. There is a general acknowledgement of two broad varieties of Singapore English. One is an internationally intelligible variety usually used in more formal contexts or in communication with non-Singaporeans and is referred to in the literature either as ‘standard Singapore English (SSE)’ or ‘educated Singapore English’. The other is an informal casual variety, a vernacular form commonly known as and synonymous to ‘Singlish’ or ‘colloquial Singapore English (CSE)’ (Gupta, 1994; Low &

Brown, 2005). Since the late 1970s, there have been continual concerns in the education system over the standards of English amongst Singaporeans with many views expressed against Singlish. This also translates to the society as a whole and is, today, evident in the presence of a range of government-proposed initiatives, cover stories in television programmes and discussions in local newspapers, online forums, and social media related to the varieties of English used in Singapore. A clear indication of the extent of these concerns is the on-going Speak Good English Movement (SGEM), first launched in 2000. However, it is interesting to note that while its aim to improve the quality of written and spoken English in Singapore is widely embraced, the SGEM has also faced criticisms from various linguists (Chng, 2003; Lim, 2009; Rubdy, 2001) who claim that it fails to recognize the possibilities of the co-existence of varieties and their appropriacy in different situations (Low, 2012). This dichotomous view has been a popular focus for many academic studies and also social debates. More recently, however, there appears to be a swell in nation-wide pride towards Singlish following the inclusion of Singlish terms in the Oxford English Dictionary (The Straits Times, 2016), throwing more implications into the mix of discussions on standards, colloquialism, and language attitudes and identity in SgE. Although not the main focus of this study, some of these areas will be briefly discussed in Chapter Six.

Various models, albeit taking different approaches, have been posited to describe the variations in SgE. Gupta's model (1994) depicts variation in SgE as a diglossic situation. She describes an existence of an H (High) variety (i.e. Standard Singapore English) and an L (Low) variety (i.e. Colloquial Singapore English/Singlish) which speakers are aware of and can utilise for the appropriate purposes. She also states that it might not be a distinctly binary situation but involve 'degrees of aim at H and L' (Gupta, 1994:8). Pakir (1991) portrayed variation in SgE in the form of expanding triangles which were based on clines of formality of occasion and proficiency of speaker while Deterding and Poedjosoedarmo (2000) modified Pakir's model and included a dimension to account for ethnically-conditioned variation. In their inverted triangles model, they suggest that SgE speakers are very much alike in formal speech but have ethnic-specific variation in informal speech. Another more recent model of variation in SgE is Alsagoff's Cultural Orientation Model (COM) which depicts variation in SgE as a result of two differing motivations – 'globalisation' and 'localisation' (2007, 2010). Based on Bakhtin's concept of centripetal and centrifugal forces (1981), she describes a 'global brand' – 'International Singapore English (ISE)' and a 'local brand' – 'Local Singapore English (LSE) as two varieties of Singapore English serving two different cultural orientations; one to enable SgE speakers to interact with the 'outside' world and the other to unite SgE speakers while '[differentiating] from exonormative standards' (Leimgruber, 2013:49). This quick summary of variation models gives a glimpse of variation in SgE from different perspectives and provides possible frameworks in which to discuss /r/ variation in SgE.

1.1.4 Phonetic research on /r/ in Singapore English

Phonetic research on SgE has long focused on vowel quality. Conflation of /e/ and /æ/ (Suzanna & Brown, 2000) and conflation of the vowels in FLEECE and KIT (Deterding, 2003) have been found in SgE. However, the former appears to be characteristic only of ethnically Chinese Singaporeans while variations exist for Singaporean speakers of other ethnic groups. Monophthongisation is also common in SgE, for example, typically in the vowels of FACE and GOAT (Deterding, 2000; Lee & Lim, 2000; Lim & Low, 2005). Earlier studies of consonants in SgE have included investigations of the replacement of dental fricatives /θ/ and /ð/ with their corresponding alveolar plosives /t/ and /d/, and vocalisation of dark /l/ (Tan, 2005). Research on final nasal deletion and nasalization of preceding vowels, as well as simplification of final consonant clusters (Deterding, 2007; Lim, 2004; Wee, 2004) has also been carried out. However, little has been done in the study of rhotics in SgE.

Existing studies (e.g. Lim, 2004; Tan & Gupta, 1992) focused largely on impressionistic studies of postvocalic /r/ and its attributive social factors. Although SgE is formally recognised as a non-rhotic accent (Low & Brown, 2005), some use of postvocalic /r/ has been reported. In SgE, rhoticity has been found to indexically signal high prestige (Tan & Gupta, 1992) and formality (Lim, 2004), and also higher education level and socioeconomic status (Tan, 2012). It has been reported to be used especially by young SgE speakers (Poedjosoedarmo, 2000a) and generally viewed as either trendy (Deterding, 2007) or pretentious (Eu, 2004). No systematic study has been done, however, to ascertain the speaker profile of and motivation(s) for the postvocalic /r/ in SgE.

Moving beyond the distributional aspects of /r/ in SgE, Kwek (2005) studied variants of /r/ in young ethnically Chinese SgE speakers (one male and two female) and reported the presence of a labial variant, the labiodental approximant [ʋ], in SgE that is both perceptually and acoustically different from the characteristic post-alveolar approximant [ɹ]. Deterding (2007) also found this to be true of the subject of his study, a young ethnically Chinese female SgE speaker. These preliminary studies thus brought to light an interesting feature that appears to be fast gaining widespread occurrence in the speech of this group of SgE speakers. At the same time, Kwek (2005) conducted an attitudinal study on the labiodental approximant /r/ in SgE and suggested that it was a social indicator, according to Labov's (1972) definition of the term. It was found that Singaporeans were not able to overtly recognise the labiodental /r/ variant but perceived it to be 'weak' and marginally 'non-standard' as compared its post-alveolar counterpart. A subsequent follow-up acoustic investigation of the labiodental approximant [ʋ] (Kwek, 2012) further revealed certain distinct differences in F3 frequencies and patterns between the labiodental approximant /r/ and the post-alveolar approximant /r/. While there was a distinct lowering of F3 and also a steep F3 rise into the following segment for post-alveolar approximant /r/ tokens, a low F3 and subsequent F3 rise were both absent for the labiodental approximant /r/ tokens. In addition to this, speaker sex and speech style effects on the variant of approximant /r/ used were also found. All SgE speakers studied used both approximant /r/ variants and also other intermediate variants. However, female SgE speakers were found to use the labiodental approximant /r/ more frequently than male SgE speakers, and the labiodental approximant /r/ was generally used more often in formal (i.e. read) than in informal (i.e. conversational) speech. Findings from this study contributed further understanding of the labiodental approximant /r/ in SgE. Nonetheless, phonological environments were not systematically analysed and thus effects of language-internal factors could not be discussed. Also, although an extension of the first exploratory study (i.e. Kwek, 2005), it was still a relatively small-scaled study which included five female and five male SgE speakers from only one of the ethnic groups in Singapore (i.e. Chinese) and could, therefore, only serve to give a preliminary view of what might be the story of /r/ realisation in SgE.

While there have been phonetic studies that focus on non-Chinese ethnic groups (e.g. Sim, 2015) and ethnicity-determined variation (e.g. Deterding & Poedjosoedarmo, 2000), many studies on pronunciation in SgE have focused mainly on ethnically Chinese SgE speakers as a representative sample, based on the fact that they make up the majority of the population. However, although this allows the control of the ethnic group variable, it definitely has limitations in investigating the likely effect of ethnicity which is an interesting aspect of SgE. To test the validity of this hypothesis, a pilot of the current study was carried out (i.e. Kwek, 2015). It compared the labiodental approximant [ʋ] and the post-alveolar approximant [ɹ] between five ethnically Chinese and five ethnically Malay female SgE speakers. This revealed ethnicity-determined variation not only in the frequency of occurrence but also in the phonetic realisations of both variants of approximant /r/. Based on raw percentage counts, ethnically Chinese female SgE speakers used more labiodental approximant /r/ while ethnically Malay female SgE speakers used more post-alveolar approximant /r/. Ethnically Malay female SgE speakers were also found to make clearer distinctions between the two variants of approximant /r/ and also had a significantly lower average F3 nadir than ethnically Chinese female SgE speakers for the post-alveolar approximant /r/. This thus lent further support to expanding the study of /r/ variation to include SgE speakers of all the other major ethnic groups in Singapore.

1.2 Aims of Study

Moving on from previous research which has mainly discussed the sociolinguistics of postvocalic /r/, this study focuses on both emerging and waning patterns of phonetic and phonological /r/ variation in SgE. Building on the earlier preliminary studies of the labiodental /r/ (i.e. Kwek, 2005, 2012), as mentioned, which provided evidence for its growing status in young ethnically Chinese SgE speakers, it continues to examine the labial /r/ variant, taking into account the effects of linguistic and non-linguistic factors on its development. At the same time, it sets out to document a more systematic account of variation in rhoticity and also explore the tap/trill variants in SgE, both of which have yet to be done in research on SgE. It includes not only ethnically Chinese Singaporeans but SgE speakers from all the four major ethnic groups in Singapore. Taken together, this study has a wider aim of not only providing empirical evidence for /r/ variation in SgE but also surfacing the need to consider a multidimensional approach in researching multicultural urban varieties like SgE.

1.3 Research Questions

The study, thus, aims to answer these research questions:

1) What are the variants of /r/ present in Singapore English?
2) How do these /r/ variants in Singapore English differ in phonotactics and acoustic features?
3) To what extent do linguistic factors (e.g. phonological position, word class, following context) affect the realisations of /r/ in Singapore English?
4) What is the role of non-linguistic factors (e.g. speech style, speaker sex, age, ethnicity) in determining /r/ variation in Singapore English?

1.4 Outline of thesis

This thesis comprises six chapters. This first chapter begins by giving an overview of the articulation and distribution of /r/ followed by a brief description of past research on /r/ in SgE. It then gives a comprehensive picture of the linguistic environment in Singapore, covering the introduction and spread of the English language, the role of education and language policies, and the status of the other three official languages (i.e. Malay, Mandarin, Tamil). Following this, variation models in SgE are presented before a brief outline of phonetic and phonological studies on consonants in SgE is given. The chapter then presents the aims and research questions of the study before the outline of the rest of the chapters of the thesis.

Chapter Two – Literature Review

This chapter reviews the relevant literature, starting with those focused on the phonetic nature of /r/. This includes an overview of articulatory features, acoustic properties, and auditory perceptions of /r/. It also presents the three models of /r/ variants. The phonotactics and phonology of English /r/ are discussed next before the chapter closes with a look at the sociolinguistics of /r/.

Chapter Three – Data and Methods

A description of the speakers and data collection process is presented first in this chapter. This includes details of the materials used as well as the recording conditions and procedures. How the segmentation and categorisation of /r/ tokens were carried out are then explained before the next two sections focus on describing the auditory coding and acoustic measurement processes.

Chapter Four – Auditory Analysis and Results

Procedures and results of the auditory analysis are presented in this chapter. It first gives an overview of the data collected before going on to a summary of /r/ realisations and variation in SgE. Following this, the strengths and limitations of two potential statistical models are discussed. Here, the role of random effects, and the nature of predictor and outcome variables in aiding the choice of statistical models for the study are highlighted. The results of the auditory analysis then follows. It first looks at the effects of phonological position, word class, following context and speech style on non-syllable-final /r/ realisations. Results from the analysis of interactions between linguistic and non-linguistic factors then follow before the chapter ends with a presentation of results from the analysis of variation in syllable-final /r/ realisations.

Chapter Five – Acoustic Investigation: Approximant /r/

Chapter Five gives a closer study of approximant /r/ in SgE. It reports the differences in F3-F2 distance between approximant /r/ variants in validation of the auditory categorisation. It first looks at the differences between the two variants of approximant /r/ (labiodental approximant and post-alveolar approximant), as well as those between them and their perceptually weaker variants in read speech. Results of a further comparison between the two perceptually strong approximant /r/ variants in both speech styles are then presented while the rest of the chapter focuses on the effects of ethnicity and speech style on F3-F2 distance for both perceptually strong approximant /r/ variants. These also serve to show finer distinctions between and within the approximant /r/ variants.

Chapter Six – Discussion and Conclusion

In Chapter Six, the research questions are first revisited. These are then addressed, first, by a presentation of the phonotactic variation, spectrographic representation and acoustic correlates of /r/ variants in SgE. The implications of the effects of linguistic and non-linguistic factors on /r/ variation in SgE are then discussed, bringing together the findings reported in Chapters Four and Five. This concluding chapter then wraps up the entire study with an outline of the limitations of the study and also suggesting future directions for further research on the topic.

Chapter Two

Literature Review

Phonetic and phonological studies on rhotics as well as reviews of related sociophonetic phenomena are presented in this chapter. Articulatory and acoustic descriptions of /r/ realisations are presented first, leading to a review of Lindau's (1985) seminal work where she showed familial resemblances within the phonological class of rhotics through acoustic parameters that form ties between/amongst the different types of /r/ variants. This is then followed by an evaluation of two other models which were developed based on Lindau's: Magnuson (2007) proposes including considerations of the role of the larynx/pharynx, and Sebregts (2014) suggests that the connections between rhotics, specifically in the case of Dutch, should be seen as family relationships instead of resemblances. Considerations that arise from auditory perception studies of /r/ are then discussed before a review of English phonological issues related to rhoticity is presented. The latter half of the chapter focuses on sociophonetic studies of rhotics, highlighting variation and change in English-speaking societies, the effects of multiculturalism on urban communities, and the history and background of /r/ in communities of linguistic environments similar and/or related to that of SgE. This chapter thus sets the foundation on which the current study of rhotics in Singapore English (SgE) is based and provides the contexts for comparative discussions.

2.1 The phonetic nature of /r/

Much has been said about the diversity of /r/ realisations within and across languages. What has proven problematic for phoneticians over the years is identifying a single determining phonetic property which is characteristic of the entire class of rhotic sounds (Ladefoged & Maddieson, 1996a; Lindau, 1985), bearing witness to Walker's (1791) earlier sentiments towards the English /r/ as 'the most imperfect of all consonants' (Harris, 1994). Two other outstanding factors contributing to this problem are 1) the fact that not only does /r/ have more phonetic variants than any other consonant in the English language (Cruttenden, 2001:207) and lacks a definite place of articulation (Ladefoged, 2005:119), a single /r/ variant can also have an extremely wide range of incongruent 'phonetic exponents' cross-linguistically (Scobbie, 2006), and 2) the descriptive quandary of sounds which function phonologically as the phoneme /r/ in some languages when there are phonetically corresponding sounds that 'behave systematically as non-rhotics in other languages' (Scobbie, 2006). Evidently, on a larger scale, as compared to the challenges inherent in describing the acoustic and articulatory realisation of /r/ given that it is 'pronounced in different ways in different dialects of English' (Ladefoged, 2005:119), defining a class of rhotics that will apply across the languages of the world is an even greater challenge. This has often led the discussion to rely on the fact that all /r/ sounds are linked solely by their orthographic representation of 'r'.

2.1.1 Articulatory description

What makes discussing /r/ realisations in the world's languages, and even more so classifying them as a single sound class, tricky is exemplified in the difficulty in assigning specific articulatory labels to the multi-faceted /r/ phoneme, for example, according to degree of stricture, place of articulation or aspect of articulation, as presented in Laver's (1994) analytic framework of segment classification. /r/ appears to be best described by what it is not, rather than what it is, resulting in researchers often discussing /r/, and phonologically-related phenomena, in relation to an 'elsewhere' concept (Halle & Idsardi, 1997; Scobbie, 2006). Under this kind of view, the most appropriate definition of the English /r/ might be that 'the label /r/ seems to be applied to oral lingual sonorant consonants unless they are specifically palatal, lateral, or labial' (Scobbie, 2006:338). Thus, according to this definition, /r/ sounds are consonantal sounds which are produced via a continuous, typically unblocked and frictionless, airflow through the mouth and articulated with the tongue, but provided that they are not articulations that involve solely the palate, the lips, or air escaping from the side(s) of the tongue. It should be stated, on the outset, that this definition is not always true to all /r/ realisations, as Scobbie (2006) also continues to state. This 'imperfect' definition is, therefore, used, in the rest of this section, as a means to provide descriptions of the different articulatory strategies in mainly English /r/ realisation while reiterating the limitations in assigning a universal definition applicable to all sounds classified as /r/.

An /r/ sound that best fits this description is the most common allophone of /r/ in British English (BrE), more specifically, and widely, known to be a voiced post-alveolar approximant [ɹ] (Cruttenden, 2014:223; Hayward, 2000:202; Laver, 1994:299; Wells, 1982). This approximant variant is produced by raising the soft palate, shutting off the nasal resonator (Cruttenden, 2014:223) and allowing airflow through the mouth. The tongue tip is moved towards, and in close proximity to, the alveolar ridge but without actual contact with any part of the roof of the mouth (Roach, 2000:62). In this articulation, the tongue is contracted causing a 'hollowing and slight retroflexion of the tip' which in turn allows an escape of airstream 'without friction over the central part of the tongue' (Cruttenden, 2014:224), and it is common for the lips to be slightly rounded (Cruttenden, 2008).

The degree of retroflexion of the tongue tip, however, varies and is usually dialect-dependent. With a larger degree of retroflexion, a distinctively 'retroflex' approximant is realized – the voiced retroflex palato-alveolar approximant [ɻ] (Cruttenden, 2014:226; Laver, 1994:299). This variant still fits effectively into the above-mentioned definition of /r/ in that it is articulated in fairly similar ways to its post-alveolar counterpart; the only difference being that there is more curling back of the tongue tip, bringing it or 'even the underside of the tip/blade to the palato-alveolar part of the hard palate' (Laver, 1994:299). This is a common realisation, for example, in the English spoken in South-West England and some parts of America (Cruttenden, 2014:226), Scotland (Lawson, Stuart-Smith, & Scobbie, 2008; Stuart-Smith, 2003), and India (Bhaskararao, 2011; Coelho, 1997). Additionally, and relatedly, studies in American (AmE) and Scottish English (ScE) (Hagiwara, 1994; Kent, 1998; Lawson, Scobbie, & Stuart-Smith, 2013) have also shown the existence of a different configuration which, however, appears to have 'a very similar acoustic and auditory effect' to the retroflex approximant (Laver, 1994:141); one that does not involve constriction at the tongue tip but at the tongue dorsum and root of the tongue. This articulation, commonly known as the 'bunched /r/' (Delattre & Freeman, 1968; Hagiwara, 1994, 1995; Lindau, 1985) or 'molar /r/' (Catford, 2001; Uldall, 1958), has no 'raising of the tongue tip or blade' (Ladefoged & Maddieson, 1996a:234) but, instead, involves a withdrawal of 'the tongue tip into the body of the front of the tongue' (Laver, 1994:141), and a raising of the mid-dorsum part of the tongue towards the palate with 'a second constriction which is regularly produced between the root of the tongue and the pharyngeal wall' (Delattre & Freeman, 1968:30).

Earlier articulatory descriptions of the American /r/, as reported in Delattre and Freeman (1968), had recognized the presence of these two American r's - the 'retroflex' and the 'bunched' /r/ but most generally considered the former as the dominant variant (Bronstein, 1960; Gleason, 1961; Heffner, 1950; Kenyon, 1940; Prator, 1957; Wittig, 1956). Even those which did acknowledge a significant role for the 'bunched' /r/ (Hill, 1958; Hockett, 1958; Thomas, 1947; Wise, 1957) had stated so with varying opinions on dialect patterning and also with little or no empirical evidence, with the exception of Uldall's (1958) palatogram analysis of the 'molar' /r/ and 'flapped' /t/. Articulatory evidence of specific variations of /r/ in AmE was therefore provided by Delattre and Freeman (1968) in their pivotal cineradiographic analysis of /r/ in various phonological environments where they identified six types of /r/ which had distinct tongue shapes but otherwise two common constrictions, albeit varying degrees, – in the palate and at the pharynx. Later studies (Alwan, Narayanan, & Haker, 1997; Guenther et al., 1999; Westbury, Hashi, & J. Lindstrom, 1998; Zawadzki & Kuehn, 1980) further support the claims of Delattre and Freeman (1968) that, instead of a categorically 'retroflex' or 'bunched' /r/, a more realistic picture of the American /r/ is that of a continuum with a range of incremental variants that lie between those two extremes (Espy-Wilson, Boyce, Jackson, Narayanan, & Alwan, 2000).

A strikingly similar situation appears to be the case for ScE. In their study of tongue shapes in ScE /r/ articulation, Lawson, Scobbie, and Stuart-Smith (2011) developed a 'new broader classificatory system', initially based on and modified from Delattre and Freeman's (1968) categories, that was applicable to their corpus. Thus, ScE is reported to have four articulatory categories of /r/ - 'tip-up', 'front up', 'front bunched' and 'mid bunched' which, although stated as discrete categories, 'might be viewed as ranges on a continuum' (Lawson, Scobbie, et al., 2011:260) as in the American context. On the two ends of this continuum are 'tip up' /r/, where the point of primary constriction is the tongue tip raised towards the post-alveolar area, and 'mid bunched' /r/, where the tongue dorsum forms the primary constriction and has a general bunched configuration (Lawson et al., 2013).

Tongue retroflexion, regardless of extent, is often accompanied by slight rounding of the lips in the articulation of /r/. While the following vowel largely determines the lip position, there are also systematic inter-speaker variations in the degree of labialisation in /r/

articulation. Labial variants of approximant /r/ thus exist as a consequence of varying degrees of labialisation or lip involvement, and can be heard in young speakers of BrE (Dalcher, Knight, & Jones, 2008; Foulkes & Docherty, 2000; Hughes, Trudgill, & Watt, 2005; Kerswill, 1996; Llamas, 2001; Marsden, 2006) and SgE (Deterding, 2007; Kwek, 2005, 2012). For labial variants that involve more defined lip-rounding, velar constrictions are also to be expected (Jones, 2005; Wells, 1982). As Foulkes and Docherty (2000) state, articulatory descriptions of these labial variants in the literature have been varied and either referred to orthographically as ‘w’ or generically as the voiced labiodental approximant [ʋ].

Besides being a result of modified lip configurations, labial variants of /r/ are also known to be distinct from the post-alveolar variant in lingual gestures. They have been described to have ‘no upward curl of the tongue tip’ (Cruttenden, 2014:85) and acoustic analyses suggest a usually less defined retroflexion of the tongue tip or even a complete lack of tongue gesture in the labial variants as compared to the post-alveolar ones (Jones, 2005; Kwek, 2012). It appears, then, that cases of a complete lack of tongue gesture would fail to comply with the ‘lingual’ part of the earlier-mentioned definition of what seems to be included under the label /r/. Implications of this for the rhotics sound class will be discussed further in the current study.

A common issue that arises in studies of the ‘labiodental /r/’ is the appropriacy of the label in relation to the actual articulation. Foulkes and Docherty (2000) report no clear evidence for retraction of the lower lip, which is required for a labiodental articulation, in the labialized variants analysed in their study on BrE and therefore suggest the bilabial fricative [β] as an equally possible transcription symbol to reflect the articulation which could have well been realized as a result of a bilabial constriction. This is in keeping with the conclusion Ladefoged and Maddieson (1996b) reached for Isoko; a similar lack of labiodental characteristic can be seen in a photograph of lip shape for one of its speakers (Ladefoged, 2003:35). Cruttenden, on the other hand, maintains the variant as an approximant and uses the voiced velar approximant [ɰ] alongside [ʋ] in descriptions of /r/ in BrE which lack an upward-curled tongue tip. In an earlier study on young ethnically Chinese SgE speakers (Kwek, 2012), a similar issue was raised and it was proposed that there exist two distinct labialised variants of approximant /r/ in SgE; one that is labiodental, where the lower lip is retracted and forms a constriction with the bottom edge of the upper front teeth, and another that is bilabial, where there is a more pronounced degree of lip rounding and protrusion. Preliminary spectrographic observations presented in that study showed that these variants have formant patterns similar to the voiced labiodental fricative [v] and the voiced labial-velar approximant [w] respectively but, at the same time, all three types are acoustically and auditorily distinct from each other, corresponding with results reported in (Jones, 2005). This inevitably brings into the picture the labiodental approximant [ʋ] used in Indian English (IndE) not as an /r/-variant but as a 'loose approximation' of /v/ and/or /w/, likely an influence from Hindi (Cruttenden, 2014) or Tamil (Keane, 2004), or as a partial merger of /v/ and /w/ (Coelho, 1997:571). It is clear, then, that there is a need for more detailed acoustic and articulatory investigations of labialised /r/ variants to pin down their relationships with other related sounds in the matter of what qualifies, or does not qualify, a sound as belonging to the sound class of rhotics.

Another point of deliberation is the labelling of /r/ sounds as sonorant. The articulations mentioned so far are approximants produced with relatively, if not fully, unobstructed continuous airflow. However, this characteristic may not always be shared by all English /r/ sounds. This is evident in the articulations of /r/ in which full contact or closures, alternations between closure and release, or higher levels of frication are necessary. These /r/ sounds are commonly known as trills, flaps, taps, and fricative rhotics.

Generally, trills are articulated neither by complete stop closures nor continued unobstructed airflow of the following three stricture types: fricative, approximant, resonant, 'but, rather, an alternation between them' (Catford, 1988). A trill involves the vibration of a flexible articulator against another surface in the vocal tract (Catford, 1988). In order for this to materialize, a sufficient airflow is required, and the soft moveable articulator needs to have correctly adjusted muscular tension and be in close enough proximity to the other surface so that when the strong current of air passes through the appropriately narrow aperture, 'a repeated pattern of closing and opening of the flow channel occurs' due to the changes in air pressure, and simultaneous tensing and relaxing of the articulator involved (Barry, 1997;

Catford, 1988; Ladefoged, Cochran, & Disner, 1977; Ladefoged & Maddieson, 1996a; McGowan, 1992). Trills can, thus, be assumed to be the product of an aerodynamic-myoelastic process similar to that of phonation (vocal-fold vibrations) (Barry, 1997; Ladefoged & Maddieson, 1996a; Laver, 1994; Spajić, Ladefoged, & Bhaskararao, 1996). The vibration is not an active gesture of the articulator but 'simply a passive response to the air stream', thus – although classified as a stop due to the period of necessary articulatory closure (Laver, 1994) – as long as a continuous airstream is ensured, trills are articulations which 'can be maintained for a long time' (Catford, 1988). By this understanding, therefore, it is arguably legitimate to consider describing trills as sonorant consonants.

There are a number of places at which trills can be articulated but the two most common trills in the world's languages are the 'lingual trill (or roll)' (Cruttenden, 2008), more specifically the voiced apico-alveolar trill [r], and the voiced uvular trill [ʀ] (Catford, 1988; Ladefoged & Maddieson, 1996a; Laver, 1994). An apico-alveolar trill [r] is produced by the vibration of the tongue tip against, most commonly, the alveolar ridge (Barry, 1997; Catford, 1988; Ladefoged & Maddieson, 1996a) and is the variant characteristic of the 'typical Italian r and the Castilian Spanish rr' (Catford, 1988) as well as the 'distinct trill phoneme' in most Indian languages (e.g. Tamil, Hindi, Malayalam) (Bhaskararao, 2011; Keane, 2004; Ohala, 1994), and the trill in different varieties of Malay: Bruneian Malay (BrunM) (Clynes & Deterding, 2011), Indonesian Malay (IndonM) (Soderberg & Olson, 2008), and Standard Malaysian Malay (MalM) (Asmah, 1977; Farid, 1980; Yunus, 1980). Although the more usual /r/ variant in BrE is, as mentioned earlier, the post-alveolar approximant [ɹ], it has been said that for some speakers of Received Pronunciation (RP) and certain Scottish accents, the typical /r/ would be an apico-alveolar trill [r]. However, contrary to popular belief, the use of this trill has also been described to be infrequent outside of 'highly-stylised RP speech' (Cruttenden, 2008) and the speech of 'stage Scotsmen' (Catford, 1988).

The active articulator for the uvular trill [ʀ], on the other hand, is the uvular which vibrates 'in a broad channel formed in the centre of the back of the tongue' (Laver, 1994:219) created by the moving up and backwards of the tongue dorsum towards the postvelar region (Barry, 1997). This variant is heard in North German, Modern Israeli Hebrew and, sometimes, French (Catford, 1988). Compared to the apico-alveolar trill [r], the uvular trill [ʀ] is even rarer in English but has been reported to be used by speakers in rural parts of North-East England (Hughes & Trudgill, 1991:34) and lowland Scotland as ‘a defective substitution for [ɹ]’ (Cruttenden, 2014:226). Other trills which are less common in the world’s languages and rarely, if not never, occur in English are articulated at other places and include the following variants: voiced bilabial trill [ʙ] (e.g. in Kele) (Ladefoged et al., 1977), voiced uvular fricative trill [ʁ] and voiceless uvular fricative trill [χ] (e.g. in French) (Laver, 1994), fricative trill <ř> (e.g. in Czech) (Laver, 1994), and palatalized trill [r^j] (e.g. Bulgarian) (Kavitskaya, 1997).

Unlike trills, taps and flaps both require a full articulatory closure/stop which impedes for a sustained period of articulation, implying that the ‘sonorant’ characteristic required for what can be labelled as /r/ sounds needs to be reconsidered. Although it has been claimed, in some occasions, that a range of corresponding tap and flap variants is resultant of ‘non-attainment of the (articulatory) adjustments required for trills’ (Barry, 1997:38), taps and, especially, flaps, can definitely be seen in many languages and dialects as articulations distinct from trills. Taps and flaps are not always differentiated from each other (e.g. Jones, 1969). However, they intrinsically represent different articulatory gestures. A tap is a very brief period of contact caused by the quick movement of an articulator against another before resuming its original position while a flap is usually defined as an active articulator hitting another part of the vocal tract in passing (Barry, 1997; Catford, 1988; Ladefoged & Maddieson, 1996a; Laver, 1994). Although there have been claims (e.g. Spajić et al., 1996) that there is no need to distinguish the two as ‘both gestures involve a single muscular contraction’, the reality that ‘a particular muscle contraction’ is not the same as ‘the state of the remaining muscular sub-system’ and that there is an undeniable gestural difference between a to-and-fro/back-and-forth movement and a passing from one position to another makes a strong case for a distinction (Barry, 1997).

The tap has been viewed to be either synonymous to a single-strike trill which is merely a reduction of gestures from a multi-strike trill (e.g. Spajić et al., 1996) or, conversely, as a ‘ballistic movement’ (e.g. Laver, 1994) where the articulation is initiated by a short contraction of the muscle at the blade of the tongue to raise the tip rapidly which is then quickly followed by a release in contraction causing the tip of the tongue to return to its original position. A typical tap articulation is the voiced alveolar tap [ɾ]. It involves the 'flicking movement of the tip of the tongue against the teeth ridge' (Catford, 1988:70) and a distinct 'central hollowing of the tongue' (Cruttenden, 2014:224). It is a common occurrence in different varieties of English (Laver, 1994); it is a typical /r/ for English spoken in Edinburgh and Glasgow (Ladefoged & Maddieson, 1996a), and found in some BrE dialects (e.g. Newcastle, Liverpool) usually for intervocalic /r/ (Catford, 1988; Cruttenden, 2014) or /r/ after consonants /θ, ð, b, g/ (Cruttenden, 2014). The alveolar tap [ɾ] is also the common articulation for /r/ in languages like Spanish, Portuguese Catalan, Hausa, Tamil, Hindi, Bangladeshi Bengali and Malayalam (Catford, 1988; Keane, 2004; Khan, 2010; Ladefoged & Maddieson, 1996a; Laver, 1994; Lindau, 1985; Ohala, 1994; Punnoose, Khattab, & Al-Tamimi, 2013). Similar to the labiodental approximant [ʋ], the alveolar tap [ɾ] can also represent a non-/r/ sound. The alveolar tap is very common in North American English (NAmE) as a /t/-realisation in intervocalic positions with voicing dependent on regional accents (Laver, 1994). It also often represents a /t/, /d/ and /n/ between vowels in AmE (Catford, 1988) but only when followed by a non-rhotic context (e.g. *city*, *lady*) because there is no articulatory need for the tongue tip to remain raised after the tap (Barry, 1997) as it returns to its original lowered position. When the following segment is rhotic (e.g. *water*, *ladder*, *banner*), however, intervocalic /t/, /d/ and /n/ in AmE is realised as a flap as it will require the tongue tip to rise from a lowered position to a more retracted position for the following [ɚ] (Barry, 1997).

Putting aside the inconclusiveness of whether taps and flaps should be distinguished from each other or treated as a collapsed category and also how closely, or if at all, they are related to trills, it appears that while taps and flaps require a complete stop to the continuous airflow and thus do not have sustainable articulations that sonorant consonants should have, the 'brief momentary contact between articulators [also] makes it impossible [for them] to maintain the contact in the way that one can for stops' (Catford, 1988). Therefore, deciding whether or not taps and flaps should be classified under the label /r/ in this sense remains problematic.

The final group of sounds that have been categorized under the rhotics family is the fricative rhotics. Being fricatives, these sounds require articulators to be of close approximation, similar to the group of approximant sounds, which is precisely adjusted and controlled (Laver, 1994). However, they, unlike the approximant variants, are produced as a result of the interaction between an appropriate rate of airflow and a very small aperture which causes the airflow to be 'turbulent and noisy, producing a 'hissing' or 'hushing' sound (Laver, 1994:244). The need for aerodynamic conditions is reminiscent of what has been earlier discussed of trills. A commonly occurring fricative rhotic is known as the post-alveolar fricative [ɹ̝] and is produced by a slight retraction of the tongue tip from a neutral position to form a constriction somewhere in the post-alveolar region with a slight 'cupping aspect to the configuration of the body of the tongue' (Laver, 1994:251). There are both voiced [ɹ̝] and voiceless [ɹ̝̊] variants of this articulation. According to Whitley (2003), this post-alveolar (retroflex) fricative is a well-known allophone of /r/ in Chilean Spanish in the cluster /tr/ sounding like /tʃ/ (Zamora-Munné & Guitart 1982:100) and Maddieson (1984) also states its presence in five languages. Ladefoged and Maddieson (1996a) report this alveolar fricative [ɹ̝] to be the standard rhotic in some urban South African English (SAfrE) dialects, likely to be the same variant described by Wells (1982:616) as a nonsibilant fricative [ɹ̝] which he also stated as present in SAfrE. This fricative variant appears to also be heard in many accents of English as the /r/-realisation when /r/ is preceded by /d, p, t, k/ in syllable initial consonant clusters and also possibly, in rapid speech, across syllable boundaries (Cruttenden, 2014; Laver, 1994). From the description of its articulation, the alveolar fricative seems to be a misfit in what has been described as a probable definition of /r/ sounds. However, if the frication is viewed as a product of some 'temporal overlap between the tongue-tip retraction and the aspiration phase of initial voiceless plosives', it can, arguably, be treated as 'a secondary manifestation of an already established post-alveolar approximant' (Barry, 1997:42) and therefore is befitting of the definition for inclusion to the group of /r/ sounds. While the approximant /r/ can be fricated, as just discussed, frication seems to be more typically characteristic of non-trilled variants of uvular and velar /r/ (Scobbie, 2006). Uvular fricative [ʁ] is usually a marker of the English of Sierra Leone and of the Northumberland dialect spoken in the North-Western of England (Ladefoged & Maddieson, 1996a). It may also be used, together with the uvular trill [ʀ], by speakers in rural areas of North-East England and in lowland Scotland (Cruttenden, 2014).

The discussion so far, thus, highlights the multi-faceted, and sometimes ambiguous, nature of /r/ articulation clearly resulting in phonetically distinct variants of /r/ and causing controversy in the identity of the rhotics class. It does, however, aid in surfacing the range of possible /r/ variants to be expected and considered, in the case of this study in SgE. In the attempt to further understand the wide range of sounds that belong to the class of rhotics, and also make informed decisions on which acoustic cues would be most appropriate for analyses in the study of SgE /r/ variation, similarities and differences in the acoustic properties of these sounds as well as the practicality and reliability of acoustic measures will be considered next.

2.1.2 Acoustic properties

Vocal tract constrictions that occur in the articulation of the most commonly-occurring /r/ variant in English – the approximant /r/, are no smaller than those for vowels. (Lindau, 1985; Scobbie, 2006). This relatively unconstricted articulation usually results in a prominent formant structure for approximant /r/ realisations (Raphael, 2005), similarly found in vowels. Due to these similarities in articulatory properties, the approximant /r/ is known to behave like a vowel, hence the term 'semi-vowel' (Scobbie, 2006). Nonetheless, semi-vowels are distinct from vowels despite sharing various similarities with diphthongs especially. While diphthongs often have a long steady-state, prevocalic semi-vowels are generally initiated with a brief, steady-state segment of 30-50ms (O'Connor, Gerstman, Liberman, Delattre, & Cooper, 1957). The rate of formant frequency change is also faster for semi-vowels than for diphthongs (Liberman, Delattre, Gerstman, & Cooper, 1956). In comparison to its semi-vowel counterpart - /l/, however, this 'relatively rapid acoustic change' is recognisably slower for approximant /r/ (Kent & Read, 1992:138). This meant that there is likely to be a decently clear and substantial spectrographic picture for the approximant /r/ realisation, making formant measurements possible in the acoustic analyses and descriptions of approximant /r/.

More particularly, the approximant /r/ is described as 'lack(ing) the sudden weakening of the upper formants and shifts in the formant pattern' as seen in nasals and some allophones of /l/, and as having 'more gradual transitions' that 'make it more similar to the other semi-vowels /w/ and /j/' instead (Hayward, 2000:203), possibly explaining the analyses of formant transitions in acoustic studies of approximant /r/ (e.g. Kwek, 2012). However, it is important to note here that the rate and patterns of the segment's formant transitions are also largely dependent on its surrounding vowel context and syllable position (Scobbie, 2006).

An overview of the relationships amongst the segments as described here is probably best understood from Laver's representation of the 'distinctions between contoids and non-contoids, and within non-contoids, between approximants and vocoids' (Laver, 1994:147). Laver (1994) uses 'approximant' and 'contoid' as defined by Ladefoged (1964) and Pike (1943) respectively, but with slight differences from their originally intended meanings. He classifies [ɹ] as a 'non-syllabic approximant' alongside [w] and [j], dark /l/ as a 'syllabic contoid', and light /l/ as a 'non-syllabic contoid' (see Laver, 1994 for full diagram).

The above discussion thus suggests that approximant /r/ realisations are likely to be acoustically characterised by the presence of prominent steady-state upper formants, with gradual obvious transitions into and out of the /r/ segments. The acoustic cue that most commonly distinguishes approximant /r/ from all the other semi-vowels, nonetheless, is frequency of the third formant (F3) which changes into and out of an approximant /r/ segment (Lisker, 1957; O'Connor et al., 1957). In acoustic studies of rhotics (e.g. Espy-Wilson et al., 2000; Harrington, 2010; Johnson, 2003; Ladefoged, 2003), a distinctly lowered F3 appears to be used as the most characteristic acoustic correlate of variants of approximant /r/. As found previously (e.g. Foulkes & Docherty, 2000:49; Ladefoged, 2001:184, 2005:55; Nolan, 1983), F3 of approximant /r/ for male speakers is commonly below 2000Hz, about 1600Hz – 1700Hz and occasionally as low as 1500Hz. It is also usually just above F2. The expected lowering of F3 is caused by pharyngeal and/or post-alveolar constrictions (Stevens, 1998), and is usually accompanied by a lowered second formant (F2) caused by lip-rounding (Scobbie, 2006). For the speakers in his study, Nolan (1983) found that for approximant /r/, and not /l/, that F3 tends to be low when F2 is low. Evidence for lowered F2 and F3 have been found by, among others, Nolan (1983) for BrE /r/, Lindau (1985) in the approximant /r/ of Californian AmE and Izon speakers, and Kwek (2012) for the post-alveolar approximant /r/ in SgE. In addition to the 'unusually low F3' (Hayward, 2000:203) and lowered F2, the approximant /r/ is also usually characterized by the steep rises of both F2 and F3 towards the following vowel (Cruttenden, 2001:207; Ladefoged, 2001:184) and a close proximity between F2 and F3 (Heselwood, 2009; Heselwood & Plug, 2011; Jones, 2005; Lisker, 1957; O'Connor et al., 1957; Stevens, 1998). Caution, however as explained above, needs to be taken with the former.

Although controversial, it is common to find phoneticians claiming a more or less direct correlation between the degree of rhoticity and a lowered F3 or a small difference in F2 and F3 frequency (Ladefoged, 2003; Lawson et al., 2013). As Delattre and Freeman (1968) state, according to Lehiste (1962), 'the articulatory correlate of the low F3 position and the small separation in frequency between F2 and F3 probably is retroflexion'. This is probably because there have not been other more suitable and/or reliable acoustic correlates. Besides the post-alveolar approximant [ɹ], other approximant variants that result from anterior lingual configurations are the retroflex approximant [ɻ] and the bunched /r/ (Scobbie, 2006) as discussed in Section 2.1.1. Differentiating between a post-alveolar approximant and a retroflex or bunched /r/ can, therefore, be said to be dependent on the extent of F3 lowering, and proximity of distance between F2 and F3. As mentioned earlier, although articulated with different tongue gestures, the retroflex /r/ and bunched /r/ are similar, and are often hard to distinguish, both acoustically and auditorily (Delattre & Freeman, 1968). One then would expect similar acoustic cues for both; this is evident in Knight, Dalcher and Jones (2007) acknowledging that speakers of AmE articulate /r/ in a range of ways, in a continuum from one with a bunched tongue to one with a retroflex tongue shape, while continuing to state a low F3 which is in close proximity to F2 as the most prominent acoustic feature of the AmE /r/. However, Zhou et al. (2008) later found that while the retroflex and bunched /r/ are 'indistinguishable for the first three formants', they show differences in F4 and F5 patterns. Other than segment internal cues, retroflex and bunched /r/ can also be characterized by the long transitions flanking the /r/ segment, especially so in a case where /r/ is preceded by a high or front vowel (Scobbie, 2006). These transitions can resemble a diphthongization of the preceding vowel and help signal the presence of a following /r/ as much as the /r/ segment itself does (Scobbie, 2006). This thus encourages the replacement of the retroflex /r/ with a centering diphthong, establishing the link between /r/ and schwa, and also the coalescence of non-high vowels with /r/, resulting in a rhotacized vowel (Scobbie, 2006). This rhotacized vowel mentioned appears to include both what Catford (1988) distinguishes as retroflexed and rhotacized vowels. The difference between the two, according to Catford (1988), lie in tongue configurations which are reflective of those in retroflex and bunched /r/ respectively. However, the former affects only open vowels (e.g. [ɔ˞] as in 'board') and the latter is found only as [ɝ] (e.g. as in 'bird'). As the current study's focus is not on distinguishing tongue gestures, it does not differentiate the two, following the likes of Laver (1994), Wells (1982) and Trask (1996), and uses the term 'rhotacized vowel' to include both types as did Scobbie (2006). Rhotacized vowels are generally characterised acoustically by a distinct low F3 (Trask, 1996).

The descriptions so far show strong evidence for a lowered F3 as a vital acoustic cue to approximant /r/. However, this does not always seem to be generalisable to all approximant variants of /r/, much less to the other /r/ sounds. A study of Edo voiced alveolar approximants showed undisturbed stability in higher formants which is in direct contrast with the presence of marked lowering of higher formants in its voiceless/voiced alveolar fricatives (Ladefoged & Maddieson, 1996b). Even retroflex approximants, in which an F3 lowering even more pronounced than that in post-alveolar approximants is expected, display high third formant patterns in Arrernte (Ladefoged & Maddieson, 1996a). The apical approximants in Degema and Standard Swedish have also been found with relatively high spectral peaks, an indication that 'the place of constriction was not like those that produced the type with the lowered third formant' (Lindau, 1985). What arises here is that differences in these /r/ variants could also be caused by differences in the 'topography' of the tip-blade part of the tongue and not the place of articulation, and this should therefore also be considered. Studies of the labiodental approximant /r/ also serve as an example of the unreliability of F3 lowering as an acoustic cue for rhotic sounds. The labiodental approximant [ʋ] which is clearly different from the more common post-alveolar approximant [ɹ], specifically in that it lacks an 'upwards curl of the tongue tip' (Cruttenden, 2014:85), has a distinctly higher F3 frequency of about 2200Hz (Foulkes & Docherty, 2000:49). This is evidenced in acoustic studies done on the labiodental approximant [ʋ] in BrE spoken in Newcastle and Derby (Foulkes & Docherty, 2000), and in Standard British English (SSBE) (Jones, 2005) as well as in SgE (Kwek, 2012). While the labiodental approximant /r/ in BrE does not have the F3 lowering and F2 raising of the post-alveolar approximant /r/, it is still found to have a closer F2 and F3 proximity than a /w/ which it has been shown to share similarities with (Knight et al., 2007). In fact, in a comparative study done on the labiodental approximant /r/ and /w/ (Dalcher et al., 2008), it is suggested that, for some speakers, there is a possibility for the proximity of F2 and F3 to be a sole determining acoustic cue for an /r/ realisation and that the height of F2 instead of F3 would be more salient in the identification of an approximant /r/. It should be noted that there are implications of speaker dialects and this will be further elaborated in Section 2.1.4.

Trills, although characteristically the 'most prototypical members of the class of rhotics' (Ladefoged & Maddieson, 1996a), are not necessarily always signalled by a lowered F3 either (Lindau, 1985). Dental trills typically have high third formants, as do the alveolar trills in Hausa and uvular trills in Southern Swedish (Ladefoged & Maddieson, 1996a). However, some palatalized alveolar trills and retroflex trills, for example in Toda, are found to have lowered F3 (Ladefoged & Maddieson, 1996a; Spajić et al., 1996), making a lowered F3 a pretty inconsistent acoustic cue to rely on. The more reliable acoustic feature of trills is the presence of periods of vibration. Apical trills are typically known to consist of two to three periods of vibration, although having only one or more than three is also possible. Single- and multi-strike trills occur as 'stylistic variants' in ScE and some regional accents of German (Barry, 1997:40). Each period of vibration consists of a closed phase during which the articulators are in contact, succeeded by an open phase in which they are slightly apart. These are observable in spectrograms where closed phases appear in light shades due to weak or absent formant energy, and dark shades caused by concentrations of energy in characteristic formant regions signal open phases; each lasting for about 25 msec (Ladefoged & Maddieson, 1996a).

From an acoustic point of view, Lindau (1985) has found, based on an average calculated from about 50 speakers of Swedish, Spanish, Hausa, Degema, Edo, and Kalabari, that an apical tap lasts 20msec, making it look very much like the closure phase of a trill which, based on the average of 25 speakers of the six languages, also lasts 20msec. Therefore, based on durational descriptions, acoustic similarities between taps and trills can be seen. This relationship is further enhanced by the fact that, especially in intervocalic positions, a tap frequently exists as a variant of a trill (Lindau, 1985). From these, as well as in the Catalan data of Recasens (1991), it seems that there are valid reasons to analyse a tap as a 'single-strike trill' or that 'a trill can be regarded as a series of taps' (Lindau, 1985:166). However, also, as seen from Recasens (1991) as well as from the discussion on the articulation of taps as described in Section 2.1.1, it would be dependent on the articulatory nature of the tap/trill; a tap could also be treated as being produced through an entirely different articulatory gesture and not merely a 'reduced relation of the trill' (Barry, 1997:41). Furthermore, there are languages (e.g. Swedish and Bụmọ) where a common variant of the trill is one which is articulated as a single closure, not with multi-strike gestures, but is distinct from taps due to the presence of a following prolonged opening phase (Barry, 1997). Nonetheless, analyses of formant frequencies are, thus, not as vital as that of the number and duration of periods of closure when studying taps and trills.

What can be concluded is that, generally, the lip-rounding together with constrictions in the lower pharynx and/or palate/post-alveolar palatal region which are involved in the articulation of the approximant /r/ variants, and not simply retroflexion, resultantly achieve an observable lowering of both second and third formants (Delattre & Freeman, 1968; Ladefoged & Maddieson, 1996a; Lindau, 1985). There are differences in articulation of the various approximant /r/ variants, however, and lowered F2 and F3 is not always found in all approximants, as seen in labiodental approximant [ʋ] in English and in some alveolar and retroflex approximants of certain other languages. Differences are also exemplified by uvular variants in Swedish, German and French which all have high third formants, sometimes close to the fourth formant (F4), and dental sounds which also display high F3 frequencies although not as high as uvulars (Fant, 1968; Ladefoged & Maddieson, 1996a). It is suggested then that due to different places of constrictions and shapes of articulators in the different articulations of /r/ variants, there is varying F3 behaviour. Herein lies the contention that F3 lowering is not always an indicative acoustic property of /r/ articulations. It is thus established that alongside F3, patterns of F2, F2 and F3 transitions, the distance between F2 and F3, and patterns of F4 and even F5, whichever acoustic cue/cues is/are relevant for the variant studied, should also be considered in the acoustic analyses of /r/ sounds.

2.1.3 Models of rhotics as a unified class

From the discussion of articulatory and acoustic characteristics of sounds which fall under the term ‘rhotics’, we can draw the conclusion that, from a phonetic perspective, ‘the rhotics form a heterogeneous group’ (Lindau, 1985:158). It had appeared difficult to identify a single articulatory property for all rhotics and so it was thought that they could be associated by a unifying acoustic property instead (Ladefoged & Maddieson, 1996a). A lowered F3 which was identified as the strongest contender was subsequently found only to ‘signal a particular set of articulatory configurations’ and, since rhotics exist as products of such a wide range of articulatory gestures, low F3 was deemed not ‘a good candidate for a property that unifies the rhotic class' (Ladefoged & Maddieson, 1996a). Analysing third formant behavior and frequency in relation to those of the other formants and surrounding segments, however, remains applicable to studies of most approximant and fricative variants. Despite the challenges mentioned, rhotics continue to exist as a legitimate natural class for reasons that Scobbie (2006) succinctly states – 1) A number of phonetic sounds classified as rhotics belong exclusively to the class, 2) the change in phonetic characteristics causing wide crosslinguistic variation in the same rhotic phonological element across related languages is proven to be due to diachronic change, 3) there is structurally conditioned allophony and variability of /r/ within a single language, reinforcing how heterogeneous phonetic variants can actually realise the same phoneme, 4) it is common for a single language to have sociolinguistic conditioning in /r/ variation, and 5) a range of /r/ variants is shown to be related to the development of speech from infancy to adulthood. In addition to these, it is also clear that some /r/ variants share certain characteristics with others which, separately, share other characteristics with yet some other variants of /r/, forming a network of directly- and indirectly-linked relationships. The desire to represent this web of connections between, and amongst, rhotic sounds has thus led to the formation of various models.

Lindau's model of family resemblances (1985)

In her renowned 1985 'Story of /r/', Lindau put forward a model (see Figure 2.1) reflecting exactly this sort of relationship, suggesting that the class of rhotics be seen as an extended family whose members are related by family resemblance, following Wittgenstein (1958). More specifically, this meant that some /r/ variants share certain phonetic properties and thus directly resemble each other, while other variants may not share those same phonetic properties but are still linked indirectly through sharing other phonetic properties. For example, the alveolar trill [r] and tap [ɾ] have direct resemblances as both have short closure durations while the tap [ɾ] indirectly resembles the approximant [ɹ] through the alveolar trill [r]; there is a presence of formants for both an approximant [ɹ] and the open phase of a trill. The model represents this interconnection of /r/ variants through both direct and indirect relationships across languages as well. The Southern Swedish uvular trill [ʀ] shares no similarities with the approximant [ɹ] in AmE but is strikingly similar to alveolar trills (e.g. [r], [r̥]) in the pulse patterns (i.e. phases of closure and opening). It also has 'similar spectral shapes' to the uvular rhotics (e.g. [ʁ], [χ]), displaying some form of 'spectral peak in the area of a high third formant' caused by a shared place of articulatory constriction. The approximant [ɹ], on the other hand, not only resembles the alveolar trill [r] during the period of opening but also shares its place of articulation. It is also a sonorant like the uvular fricative [ʁ]. Therefore, the uvular trill [ʀ] in Southern Swedish can be seen as indirectly linked to the approximant [ɹ] in AmE.

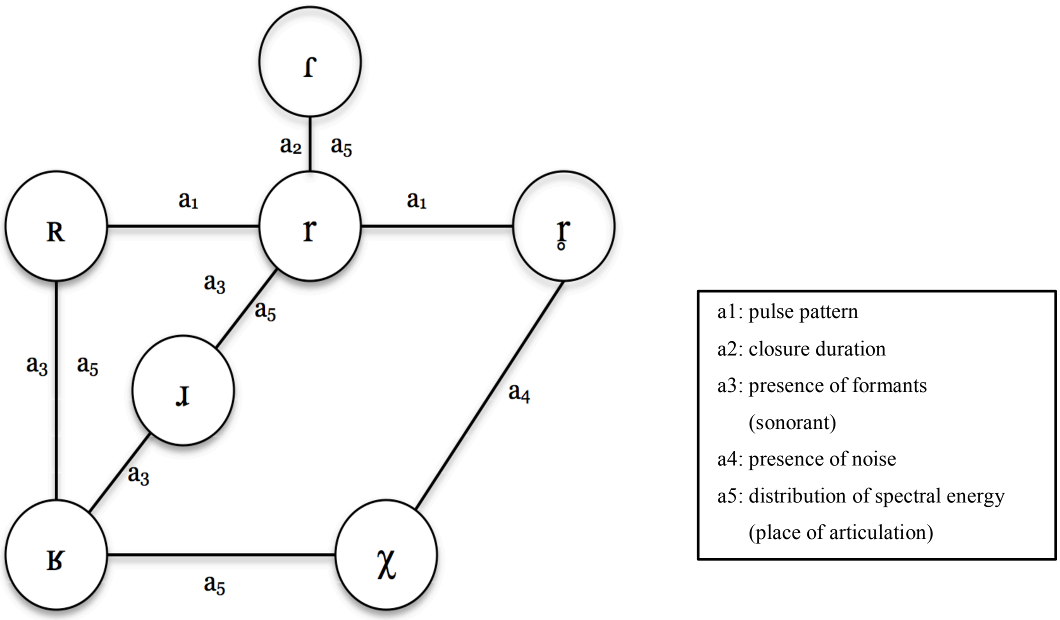

Figure 2.1: Lindau's model of familial resemblance showing parametric relations between /r/ sounds.

While this approach of family resemblance accounts for the heterogeneity of the rhotic class, 'explain(ing) well several of the synchronic alternations and diachronic changes that connect different types of rhotics to each other', it could also raise controversy as 'equally close resemblances' legitimately bring 'many sounds that are not traditionally considered members of the rhotic class' into the picture (Ladefoged & Maddieson, 1996a:245), for example retroflexed stops [ʈ], [ɖ] (Indian 't/d'). This, as highlighted aptly by Ladefoged and Maddieson (1996a), together with the previously-mentioned AmE /t/, /d/ and /n/ realized as taps/flaps, links us back full circle to an earlier claim that the only unifying factor of rhotics as a class is the historical connections and orthography, the allocated letter 'r', which represents all members of the rhotic class.

Magnuson's proposed revised family portrait (2007)

Reviewing Lindau's (1985) model, Magnuson (2007) states that it works on the premise of a 'single-tube-single-source conception of the vocal tract' and does not make any mention of the involvement of the larynx/pharynx and voicing which could potentially add salient linkages between members of the rhotics family. Thus, considering the newer notion of a two-part vocal tract system (Edmondson & Esling, 2006; Esling, 2005), he felt it necessary to rethink the model to accommodate the contribution of the laryngeal/pharyngeal vocal tract (LPVT) by incorporating three components of the LPVT: aryepiglottic (AE) fold trilling, pharyngeal modification, and vocal fold vibration. Besides including more variants of /r/, Magnuson's model (see Figure 2.2) differs from Lindau's mainly in dividing the vocal tract into two components – oral (OVT) and laryngeal/pharyngeal (LPVT). All rhotics shown in the model are covered in the OVT as they involve some configuration of the tongue in the oral cavity. Their place is, however, further refined by the rearrangement of the rhotics into two branches – left for labials and right for uvulars. Modifications in the account of manner (i.e. degree of articulatory stricture) include reinterpreting the parameters of 'pulse pattern' and 'closure duration' to 'momentary closure' and 'sustainable articulation'. Magnuson (2007) proposes two representative rhotacised vowels to be included to reflect the idea of 'vowel retraction'; as the vocalic extension of the dual vocal tract model (Esling, 2005). He also calls for a reinterpretation of Lindau's parameters of 'presence of formants' and 'presence of noise' to involve accounting for possible overlaps. In view of his proposed revised model, Magnuson also states that it should be seen as one that facilitates a discussion about rhotics as having 'a greater or lesser propensity to involve either LPVT, depending on where and how they are articulated and not as one that promotes a binary on-off setting for pharyngeal modification, or AE trilling for a given rhotic' (Magnuson, 2007:1194).

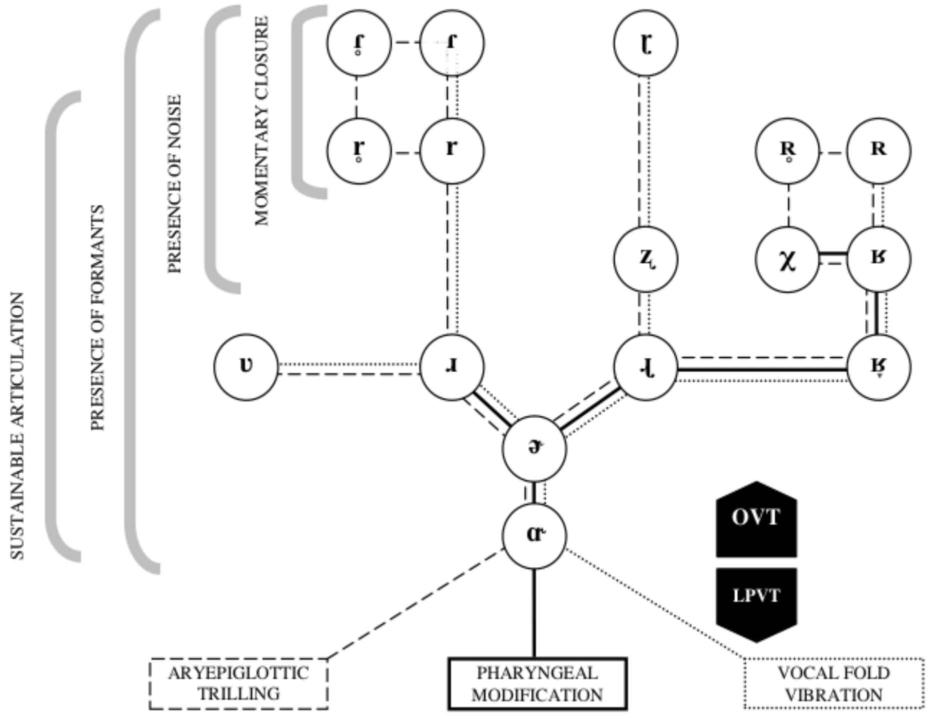

Figure 2.2: Magnuson's model of interrelations among rhotic liquids and their connection with the LPVT.

Sebregts' model of family relationships (2014)

Most recently, Sebregts (2014) claimed that although the notion of resemblance is uncontroversial, it is insufficient to characterise a sound as rhotic by relying merely on phonetic resemblance as 'many speech sounds (are) similar to rhotics in at least some phonetic property'. He argues that the family resemblance model does not help to provide a clearer explanation of how and why seemingly incongruent sounds are all able to function as the exclusive class of rhotics in their respective languages. It also does not make any predictions for the extent of differentiation between two sounds in order for them to function systematically within the same language or variety. Taking a different angle from Lindau (1985) and Magnuson (2007), who in their models attempt to account for rhotics from several languages which are not necessarily 'genetically related', Sebregts then, in aiming to explain how rhotic variation in one language – Dutch may have originated, suggested that 'instead of merely noting family resemblances' based only on common phonetic properties, depicting diachronic links between variants is also necessary and connections between variants should be considered as 'relationships rather than resemblances'. His view is that since, found in his data, 'considerable variation is possible even within an individual speaker's system' but the within-context variation for many speakers is limited, 'the distribution of the variants over different linguistic contexts (will need) explanation'. He claims that an explanation will not be possible by '(the simple) linking of phonetically similar variants' but could be relatively easily provided 'if historically related variants can be shown to predictably arise in particular contexts through common processes of language use'. Thus, his is 'an explicit model of diachronic relationships between r variants, intended to explain the synchronic patterning of r variants by showing how they may have originated'. Such relationships are established by examining the diachronic (apparent time changes in the original data used, as well as historical evidence) and geographical variation in the data. Thus, combining historical, distributional and phonetic evidence to establish the links between individual variants or groups of variants has motivated this model.

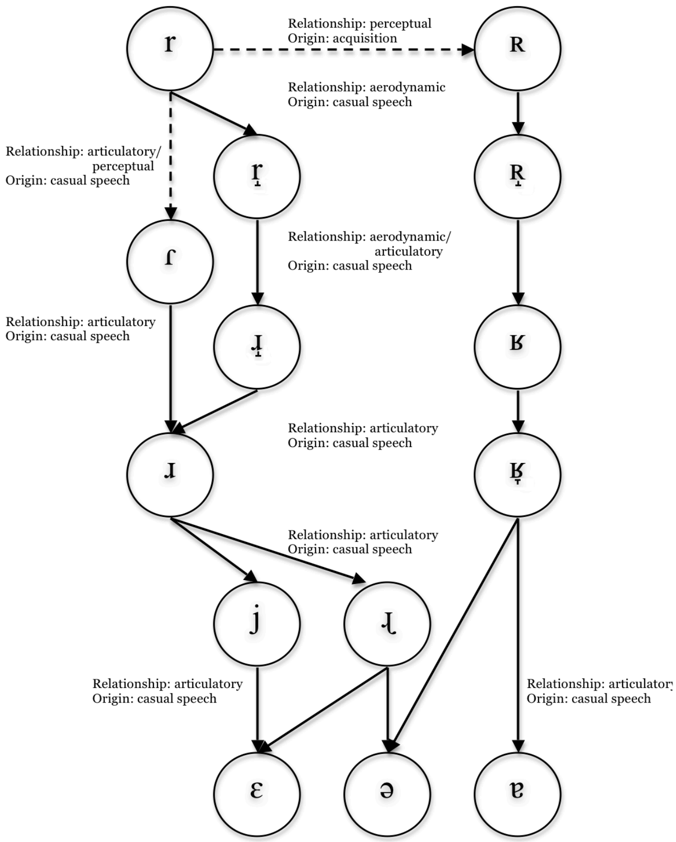

Figure 2.3: Sebregts' model of rhotic relationships

2.1.4 Auditory perception of /r/ in English

Besides articulatory and acoustic investigations, various studies have also contributed to the further understanding of the rhotics class by focusing on the role of auditory perception in the functioning of rhoticity. Heselwood and Plug (2011) suggest a refinement of the 'widely held assumption that a low-frequency F3 is a crucial acoustic and auditory correlate of rhoticity' as they found that this only held true if the low frequency of F3 contributes to the dominance of the auditory spectrum of a single peak in the acoustic F2 frequency region. At the same time, removing F3 'may in fact strengthen the rhoticity percept' (Heselwood & Plug, 2011).

Further supporting evidence for the intricacy of acoustic analysis of /r/ is seen in the perceptions towards /r/ and /w/ (Dalcher et al., 2008). In their study comparing the perceptions of AmE and BrE speakers towards /r/ and /w/, Dalcher et al. (2008) showed that a lowered F3 may not be a necessary acoustic cue for the perception of an /r/ and, at the same time, a lowered F3 may not be perceived as an indicator of /r/. Their results suggest that variation in the salience of different acoustic cues is dialect-dependent and this appears to be due to the 'presence/absence of variant forms in a speaker's linguistic environment' (Dalcher et al., 2008:70). BrE has a wider range of /r/ types, inclusive of labial variants - the labiodental approximant [ʋ], than AmE and thus BrE speakers are more likely to, if not utilise them, have a wider exposure to hearing different /r/ variants. Due to this, both groups of speakers employ different acoustic cues when distinguishing between sounds. For BrE speakers, it was found that regardless of F3 frequency, the close proximity of F2 and F3 may itself be enough to cue an /r/ when differentiating between /r/ and /w/. Height of F2, and not of F3, will thus most likely be the most salient acoustic cue for them to distinguish between a labiodental /r/ and a /w/ and 'if F2 is not sufficiently high, then a sound will be perceived as /w/ regardless of the absolute frequency of F3' (Dalcher et al., 2008:67). Consequently, Dalcher et al. (2008:69) hypothesized that F2, instead of F3, will be increasingly used to define the approximant /r/ in BrE and that 'the F2 boundary between /w/ and /r/ will become sharper in BrE relative to AmE'. AmE speakers, on the other hand, who have fewer encounters with the labiodental /r/ will 'continue to attend more to F3 than F2' (Dalcher et al., 2008:69). This therefore underlines the need, in the analyses of /r/, to consider the characteristics of all the first four formants, not only F3, in relation to each other amongst /r/ variants and also in comparison to those of other related sounds (e.g. /w/, /v/).

It appears then that the perception of rhoticity may in fact also rely greatly on anticipatory articulation cues. The importance of considering relatively long-range coarticulatory effects in speech perception has been suggested by several researchers (e.g. Hawkins & Slater, 1994; Kelly & Local, 1986). West (1999) who investigated long-range coarticulatory effects on the perception of /r/ even when the approximant /r/ and some surrounding vowels and consonants are replaced by noise, found results that 'support observations of the extent of secondary articulations' and that listeners are able to perceive long-domain coarticulatory information that distinguish /r/ and /l/ (West, 1999:405). Her study concludes that /r/ coarticulatory effects (i.e. retracted and/or raised tongue position, lip rounding and F3 lowering) are distributed across several syllables, up to two syllables, remote from the liquid; both in anticipatory and preservative directions. This then calls for the consideration of pre- and post-segmental environments in /r/ analyses as well.

Articulatory and acoustic traits of sounds belonging to the class of rhotics have been highlighted so far, inevitably foregrounding the issues that accompany attempts to substantiate their membership within the class. Through the various models proposed as well as perceptual studies carried out, it is clear that although these issues remain largely unresolved, they can be approached in certain ways in order to represent both the uniformity and variation of the relationships within the class systematically.

2.2 Phonotactics of English /r/

Other discussions of the English /r/ revolve around the distributional characteristics of /r/ in different varieties. Realisations of /r/ can occur (depending on dialect) in pre-consonantal, pre-pausal, as well as pre- and intervocalic contexts. The English /r/, in particular, is known to consist of a number of rhotic allophones for which stronger/weaker variants appear in predictable phonological environments. These have been known to be phonetically-, phonologically- or historically-/socially-determined.

Varieties of English are generally described by means of realisation of 'postvocalic r'; as r-ful versus r-less accents (Wells, 1982). This description is potentially confusing as it is applicable only specifically to this phonological environment, or rather more specifically to non prevocalic positions; varieties that are r-less may have strong r-variants (trills) while r-ful varieties may have null realisations in other phonological positions. This binary categorisation, also commonly termed as rhotic versus non-rhotic, tends to be problematic on other levels – 1) Diachronic change – Most varieties are not entirely on the extreme separate ends. While rhoticity can be more clearly traced via historical change in some varieties, it can be more variable in others (Harris, 1994), 2) Synchronic change - Some varieties are in a process of more pronounced change thus allowing for explanations of systematic variation but others are in a more fluid, unpredictable process due to competing social factors. Such /r/ variation has strongly motivated sociophonetic studies of /r/ in varieties of English (e.g. Labov, 1997; Stuart-Smith, 2003, 2007) which will be covered in more detail in a later section. Following the commonly used definitions of the terms, the current study uses 'non-rhotic/r-less accents' generally to refer to those in which /r/ is only realised in prevocalic positions and 'rhotic/r-ful accents' to those where rhoticity is present, with /r/ realisations in all positions including non-prevocalic ones.

English accents typically recognised as rhotic are, for example, those of most of the United States of America and Scotland, Ireland, Canada, Barbados, certain western parts of England (i.e. South West England, East and West Lancashire) (French, 1989; Hughes et al., 2005:45; Wells, 1982:76), and India (Bansal, 1969; Coelho, 1997; Masica, 1972). They have 'a wider distribution of /r/' which 'more closely reflects the spelling' (Cruttenden, 2014:86). Besides pre- and intervocalically (e.g. in 'racing', 'courage'), it is characteristic of these accents, in contrast to non-rhotic ones, to have /r/ occurring in pre-pausal and pre-consonantal word-final positions as in 'four' and 'cart' (Cruttenden, 2014:86; Roach, 2000:63).

Non-rhotic accents have limited /r/ distribution in which /r/ only occurs 'syllable-initially before a vowel; following a consonant, either in a syllable-initial cluster or at word or syllable boundaries or as a word-final /r/ linking with an initial vowel in the following word' (Cruttenden, 2014:224). Realisations of /r/ will thus usually occur after a consonant in syllable-initial clusters like 'bread', in the onset of words like 'really' and at syllable boundaries like ‘bedroom’. In these accents, /r/ is also commonly realised restrictively at prevocalic word-final positions where there is an orthographic ‘r’ like in ‘car ace’ or even when there is no ‘r’ as in ‘data analysis’. These word-final /r/ realisations arise from the phonological process of /r/-sandhi which will be further elaborated upon in the next section. English accents that are traditionally known to be non-rhotic include those of most of England and Wales, certain eastern and southern parts of the United States, Australia, New Zealand, South Africa, Trinidad (French, 1989; Wells, 1982:76), some parts of Scotland and Ireland (French, 1989), Malaysia (Baskaran, 2004) and Singapore (Trudgill & Hannah, 1994). More recent sociophonetic studies have, however, shown evidence of emerging rhoticity in some accents, especially those of multicultural, urban communities (e.g. SgE, MalE) (Pillai, 2015; Tan, 2012).

Although not commonly referred to, there have also been descriptions of ‘semi-rhotic’ speech (Wells, 1982:368) in ‘the accents of Humberside and parts of Lincolnshire as well as that spoken by fishermen in Flamborough, between Bridlington and Scarborough in coastal North East Yorkshire’. This phenomenon is actually more widespread than usually recognised in inland North East Yorkshire among the older agricultural population (French, 1989). In this situation, historical /r/ appears to have been lost in preconsonantal positions, ‘but retained (to some extent) in final position ___#’ (French, 1989).

2.3 Phonology of English /r/

2.3.1 /r/ systems and /r/-sandhi

Accounting for the sort of variation within the varieties of English, Harris (1994) describes the distribution of consonantal /r/ in terms of four systems. System A characterises the basic rhotic accents where constricted /r/ occurs in both non-branching and branching foot-initial onsets, and in foot-internal onsets. /r/ is grammatical in morpheme-internal, pre-consonantal position, in terms of syllabic position of the following sound rather than its phonetic quality position, and also whenever historical /r/ occurs word-finally, applicable to situations in which /r/ is followed by a consonant, an onset whose sound is characterized by some kind of consonantal constriction, a non-consonantal glide, or a pause. Constricted /r/ also appears when in morpheme-final position followed by a vowel, both word-internally and across words. Systems B, C, and D in Harris's description apply to non-rhotic accents. System B works in accents which display linking /r/ while System C applies to those in which intrusive /r/ occurs. Both systems have /r/ realisation in foot-initial onsets, both non-branching and branching, and in foot-internal ones. They diverge from System A in that constricted /r/ does not appear in pre-consonantal positions, regardless of whether it is word-internally or word-finally, and also not in word-final position before a pause. It does, however, appear in prevocalic morpheme-final position, both word-internally and across words - obligatory in the former context and optional in the latter. The outstanding, and possibly only, difference between the two systems is that System C permits the presence of the intrusive /r/ while System B does not. System D is the rarest and said to be 'characteristic of certain conservative dialects spoken in the Upper South of the United States' where constricted /r/ only appears in foot-initial onsets. Additionally, Harris (1994) clearly states that it is important to note that although these systems describe what generally is characteristic, there are 'different degrees of variability' in the realisation of historical /r/ within dialects, 'typically involving competition between rhotic and non-rhotic norms of pronunciation' (e.g. in parts of England, parts of the United States, and some Caribbean territories).

In studies of /r/, there is always much discussion about the phenomenon of /r/-sandhi, considering that it deals, largely, with the relationship between /r/ realisations and phonological boundaries (Hay & Sudbury, 2005), as mentioned in the discussion on the distribution of /r/. As highlighted by Hay and Sudbury (2005), most of the literature on /r/-sandhi focuses on phonological theories that involve explicit models of syllable structure, accounting for /r/ in onset position regardless of whether it is preserved or inserted (Anttila & Cho, 1998; Harris, 1994; Johansson, 1973; McCarthy, 1993). There are, however, alternative views which instead analyse the existence of /r/-sandhi processes from the angle of exemplars and word frequencies (Bybee, 2002; Hay & Sudbury, 2005; Pierrehumbert, 2002). For example, Hay and Sudbury (2005) provide empirical data on the diachronic relationship between the decline of rhoticity and the emergence of /r/-sandhi in New Zealand English, showing a gradual emergence of /r/-sandhi which overlaps with a decline of rhoticity. Their results suggest the role of r-ful and r-less exemplars in the lexicon rather than a process that can be explained by categorical phonological rules, either insertion or dropping, or underlying representations.

Non-rhoticity has been analysed to have arisen as a result of /r/-dropping before consonants, both word-internally and across words, but not affecting intervocalic /r/, even at morpheme/word boundaries. This resulted in a pattern of alternation at word-final positions; /r/ is produced if followed by a vowel but dropped otherwise. This, however, did not explain the occurrence of the intrusive /r/ where an orthographic /r/ is not present. Subsequently, the theory of 'Rule Inversion' was invoked in the attempt to account for the emergence of intrusive /r/. This rule inversion analysis (e.g. Johansson, 1973; McMahon, 2000a, 2000b; McMahon, Foulkes, & Tollfree, 1994; Vennemann, 1972; Wells, 1982) assumed that coda /r/ is not present in the underlying form, and that an /r/-insertion, instead of /r/-dropping, rule accounts for surface /r/ after words which have an orthographic /r/ in word-final positions. The alternative approach to 'rule inversion' is to view /r/-null alternation as a result of coda /r/ being underlyingly present for words in which it occurs. This view has been taken by the likes of several scholars (e.g. Donegan, 1993; Gick, 1999; Giegerich, 1999; Harris, 1994) and claims that the intrusive /r/ is the result of reanalysis on the part of listeners who analogously transfer the patterning of /r/ in words that have an orthographic /r/ to their homophones which do not. The next two sub-sections will further detail the processes of /r/-dropping and /r/-insertion.

2.3.2 Ellipsis/Dropping

To further understand the processes of /r/-sandhi, a more in-depth look at what happens with coda /r/ is necessary. Several accounts have been proposed. One such process, as mentioned, is /r/-dropping. It refers to the elision of /r/ in non-prevocalic positions (Wells, 1982:218) which results in non-rhoticity. In this view, non-rhoticity is regarded as a type of weakening (Harris, 1994). The coda is traditionally viewed as the 'target site' at which this process is birthed, as been hypothesised to be the case with other types of lenition. This view, according to Harris (1994), stems from the argument that 'weakening processes are primarily triggered not by segmental or boundary conditions but by aspects of constituent structure'. Pre-pausal and pre-consonantal contexts are collapsed into a single context of the rhyme. This then allows for the application of the rule of a 'delinked' /r/ whenever it occurs in a rhyme, accounting for 'a surface distributional difference' in rhotic and non-rhotic dialects where constricted /r/ appears in both onsets and rhymes for the former but only in onsets for the latter. We therefore need to consider the process of resyllabification to ensure this rule is extendable to the /r/-null alternation in /r/ realisation at morpheme boundaries. Harris (1994) thus concludes that although problems that arise from this method of analysis can be prevented by some form of rule ordering, a simpler alternative would be to assume that '(a) the delinking of r occurs freely wherever its structural description is met; and (b) it does not entail immediate deletion', allowing for /r/ 'to be delinked on the inner cycle and then subsequently relinked should a vacant onset become available on a later cycle'; should there be a delinked /r/ which had failed to be linked to an onset on any cycle, its resultant deletion will occur at the end of derivation. From this analysis by Harris (1994), rhotic and non-rhotic dialects appear to have very similar underlying representations for the phonological distribution of /r/. /r/ can appear in rhymes and onsets for both, and the lexical incidence of /r/ is also 'identical in onsets and in morpheme-final position'. The only apparent difference is that /r/ occurs before a morpheme-internal consonant in rhotic but not in non-rhotic dialects (e.g. cart).

2.3.3 Epenthesis

Some non-rhotic dialects, however, lack a distinction between alternating Vr]-V] and non-alternating V]. A prominent consideration in this process, according to Harris (1994), seems to be the underlying status of /r/ which appears, pre-vocalically, in words 'ending in a particular class of vowels in pre-consonantal or pre-pausal positions'. This has implications for the type of rule applied to the context - either deletion or insertion. He suggests that the most standard treatment is to consider this as /r/-insertion where the 'surface distribution of morpheme-final r is allegedly fully predictable'. Here, realisation of /r/ is 'dependent on the quality of the preceding vowel rather than vice versa' and, therefore, the need to analyse underlying representations of /r/ in this context is in fact unnecessary. In this case, 'r only appears after non-high vowels (regardless of morpheme-final or –internal positions) or r is inserted into an unoccupied onset, provided that it is preceded by a non-high vowel'. Intrusive-/r/ can also be qualified as an insertion of /r/ as a 'default hiatus-breaker in the absence of a locally available high glide' as found in sequences like 'fee of'. However, he argues that the process of epenthesis fails to clarify which is affected by which in the process of intrusive-/r/; is it a case of /r/ influencing the lowering of preceding vowel or one where a non-high preceding vowel encourages a following /r/-realisation. He also raises the question of why epenthesis in final coda happens with /r/ rather than some other coronal (such as /t/ or /d/). To address this, he suggests the concept of 'Floating r' which basically treats /r/ as a segmental unit without a permanent syllabic attachment. This deviates from the traditional rule-based accounts and presents as an attractive alternative. However, it has some inherent problems in modelling some aspects of the intrusive-/r/ phenomenon, as explained by Foulkes (1997).

All theories described so far, with the exception of Anttila and Cho's (1998) analysis, assume that 'word-external /r/-sandhi processes are obligatory in the dialects that contain them' (Hay & Sudbury, 2005:801). This, however, is in direct opposition to the reality as documented by descriptive dialectal studies which show the presence of variation in these processes due to both language-internal and language-external conditioning, and also the fact that some dialects have both /r/-sandhi processes while others only display the linking /r/. It is evident, therefore, that sociolinguistic conditioning needs to be taken into account.

2.4 The sociolinguistics of English /r/

2.4.1 Historical change and emergent variation in rhoticity

A common topic of study when discussing sociolinguistic variation in present-day English accents is the distinction between r-fulness and r-lessness, which has been reported to 'co-[vary] with local social categories' (Lawson, Stuart-Smith, Scobbie, Yaeger-Dror, & Maclagan, 2011). However, this cannot be done without first reviewing the historical journey of /r/ and the sociolinguistic issues of rhoticity that arise from that.

Evidence of a widespread, consistent postvocalic /r/ in BrE can be found in transcriptions of texts from the sound systems of Classical Old English, Middle English and Early Modern English dating back to as early as about AD 900, as provided by Cruttenden

(2008:70–72). However, there is evidence for the weakening of /r/. A stark change was seen in the distribution of /r/ during the eighteenth century. Then, the postvocalic /r/ was retained by educated people in their careful and literate speech, and remained associated with prestige and elegance but concurrently started on a process of vocalisation in the speech of the Cockneys, lower classes and illiterate (Mugglestone, 2003:87). Subsequently, however, it became 'fashionable in the Southeast of England to drop postvocalic /r/' (Ladefoged, 2006:92) and an exact reverse situation in terms of prestige correlation was seen. A higher rate of postvocalic /r/ usage became indicative of a lower social status (Foulkes & Docherty, 2006:411; Wells, 1982:35), resulting therefore in its absence in the emergent RP of the nineteenth century (Mugglestone, 2003:87). Accents in the UK, alongside RP, that ended up losing both preconsonantal and word-final /r/' include 'most of South East England, the Midlands and the largest area of the North' while those of Scotland, South West England, and East/West Lancashire retained /r/ in non-prevocalic positions and 'remain unaffected by the [sound] change' that happened to the consonant /r/ during the eighteenth century (French, 1989). There are also variations in the rhotic situation of these regions, however, and non-rhotic sub-varieties of Scottish and Irish speech do exist (Bertz, 1975; French, 1989; Romaine, 1978). R-fulness/Rhoticity is, thus, said to occur in accents of the latter group which are widely termed as rhotic accents, and r-lessness/non-rhoticity is found in those in the former which are known as non-rhotic accents as mentioned earlier in Section 2.2.

While it was losing its popularity in most parts of Britain, the postvocalic /r/ found its way into the United States (Ladefoged, 2006:92). Varieties of English spoken in most parts of America, today, are characterised as rhotic accents, with the exception of certain areas, for example New York and Boston which possess traditionally non-rhotic accents. The postvocalic /r/ enjoys a high level of prestige in non-rhotic accents of AmE and it is the upper-class who display a higher rate of this distribution pattern. This is in direct contrast to the situation in BrE (Labov, 1994; Wells, 1982). More specifically, the presence/absence of /r/ realisation in non-prevocalic positions, as outlined by Lawson et al. (2011), has been found as an index of the following:

- Local identity on either side of the Scottish-English border (Llamas, Watt, & Johnson, 2009) and in East New England (Irwin & Nagy, 2007)
- Ethnoracial identity (Cutler, 2010)

- Age and level of education in Southern AmE (e.g. Feagin, 1990; Strand, Wroblewski, & Good, 2010)
- Integration/Segregation of White and African American speakers in North America (Hinton & Pollock, 2000; Pollock & Bernie, 1997)
- Socioeconomic status and speaker gender in AmE and ScE (Labov, 1966, 1972; Stuart-Smith, 2003)

Comparable, but more locally-relevant (e.g. local/ethnoracial/social group identities, age, speaker sex, level/place of education), situations can be hypothesized to occur in SgE considering the fact that research shows SgE to be a non-rhotic accent with highly-observable rhotic influences (e.g. Kwek, 2012) – a point to be elaborated upon shortly. Similar social factors that contribute to variation in rhoticity have also been reported in studies on contact varieties in the UK. The role of social identification was found to play a significant role in the degree of rhoticity employed by British Punjabi-English speakers of London English (Hirson & Sohail, 2007) while variation in rhoticity found in Bradford English spoken by Punjabi-English bilinguals appears to be representative of the speakers' acquisition of a contact variety rather than the effects of bilingualism (Kirkham & Wormald, 2015). This nature of cross-linguistic and contact variety influences on rhoticity, and in fact can be extended to the general variation of /r/, is similarly applicable to the SgE context given its multicultural, multilingual environment and the fact that its speakers have, at the very least, influences from their grandparents/great grandparents who speak/spoke English as a contact variety – some speakers, especially those from the upper age group still do, themselves, speak English as a contact variety.

In this review of rhoticity, it is also relevant to note that variation in rhoticity in Asian varieties of English has also been shown to display sociolinguistic variation. For the purposes of this study, the focus will be on varieties in countries of which SgE speakers have ancestral links to and/or on those that share similar linguistic environments and/or social influences to SgE (e.g. similar English language status, English in a bilingual/multilingual context). Sociolinguistic variation in rhoticity is particularly evident in what is termed 'General/Educated Indian English' which is known to be a rhotic accent (Coelho, 1997). Rhoticity in this accent, however, is variable and has been reported to have gone through changes due to 'socio-political influences' (Chand, 2008). It was hypothesised to have experienced a decline in prestige as non-rhoticity in Delhi has been linked to 'younger females with more English medium schooling' and also 'characteristic of prestigious speakers of Indian English' (Sahgal & Agnihotri, 1988). However, the absence of postvocalic /r/ was more recently found not to be indicative of prestige as all participants in a study of English spoken in Perambur, a neighbourhood in Madras, which has mostly Anglo-Indians whose native language is English, collectively demonstrated non-rhoticity, regardless of social class (Coelho, 1997:576). Based on the socio-historical background of IndE, the most intuitive explanation for non-rhoticity is influence from BrE, both 'Standard BrE as well as non-standard r-less BrE dialects' (Coelho, 1997:576), and the hypothesis presented for its rise is the effect of social interaction; since r-lessness was found to occur more commonly in the English spoken by the Anglo-Indians than in other varieties, it could be due to the 'higher opportunity for informal social contact' that Anglo-Indians have with the British (Coelho, 1997:586). However, this proposition remains uncertain as younger generations of IndE speakers in urban Delhi 'appear resistant to notions of an external standard for their English' (Chand, 2010). It is only clear that IndE is undergoing a change to becoming less rhotic due to social factors but it is unsurprising if it is not towards an RP model (Chand, 2008). It can be seen through this discussion that rhoticity in IndE is variable, very much like in SgE although in a reverse fashion. Thus, IndE can probably be said to be a rhotic variety with observable non-rhotic behaviour. What is common between the two varieties is that variation is possibly conditioned by a combination of linguistic environment and speaker identity.

Rhoticity was not listed as a feature in earlier descriptions of Bruneian English (BrunE) (Mossop, 1996 in Rosdiana, 2008:138) but it was found to be prevalent in the speech of ethnically Malay and ethnically Chinese Bruneians in recent studies (Rosdiana, 2008). Its rise was attributed to a possible influence of American media and Bruneian Malay (BrunM), a variety which is generally rhotic and spoken by Bruneians regardless of ethnicity (Rosdiana, 2008). Salbrina and Deterding (2010) also report finding postvocalic /r/ in BrunE but state that there is 'little evidence of widespread adoption of an American accent in Brunei'. Since their results showed more rhoticity in BrunE than in SgE, in addition to the fact that BrunM is a rhotic/r-ful variety while the Malay spoken in Singapore is not, they conclude that there is a high likelihood that BrunM contributes to the presence of postvocalic /r/ in BrunE. However, they note that it is perhaps 'naïve' to claim a single source of influence for a feature in an 'emergent variety of English' and, thus, like Rosdiana (2008), suggest a dual role of AmE and BrunM in influencing the presence of the postvocalic /r/ in BrunE. Considering the parallels in the profiles of and likely influences on the community of speakers of both BrunE and SgE, this is, similarly, hypothesized to be the case of SgE, one in which rhoticity appears to be a result of cross-linguistic/cross-varietal influence.

A topic in the discussion of variation in rhoticity in Asian varieties of English that has received a substantial amount of attention is the potentially increasing occurrence of postvocalic /r/ in traditionally non-rhotic varieties. This is apparent in varieties like Malaysian English (MalE) and SgE (e.g. Phoon & Maclagan, 2009; Poedjosoedarmo, 2000a, 2000b). Phoon and Maclagan (2009) reported that a majority (9 out of 10) of the ethnically Chinese Malaysian subjects in their preliminary study of the phonology of MalE displayed rhoticity. Although the possible reasons for this were not specified, the presence of postvocalic /r/ found corroborated studies done by Hickey (2004), Ramasamy (2005) and Rajadurai (2006) who not only found rhoticity but also claimed that it is a new phenomenon with possible influences from the AmE accent (Salbrina & Deterding, 2010). With many similarities in terms of speaker profiles, cross-linguistic influences, and accent features, a similar situation would be expected in SgE. As in BrunE and MalE, rhoticity found in SgE has long been attributed to an influence of American media and studying in American universities (Poedjosoedarmo, 2000a). This appears in SgE to be, as in IndE, a sound change led by younger generations, but with a motivation that has yet to be established. Tan (2012) has found rhoticity in SgE to be an indicator of higher education level and socioeconomic status and also reports, from the results of an attitudinal study, that users of postvocalic /r/ are ranked 'very highly in terms of naturalness, likeability, intelligence and education'. This coincides with earlier observations that the use of postvocalic /r/ is associated with 'high prestige' (Tan & Gupta, 1992) and more formal situations (Lim, 2004). It also reflects reports of the use of postvocalic /r/ viewed, by young Singaporeans, as natural (Poedjosoedarmo, 1995), and 'cool' (Deterding, 2007). However, on the contrary, Eu (2004) reported the tendency of Singaporeans to view it as pretentious. In addition to this, in a pilot of the current study, ethnicity-determined variation was found in rhoticity where ethnically Malay SgE speakers display a higher usage of the postvocalic /r/ as compared to ethnically Chinese SgE speakers (Kwek, 2015). From this, it is clear that there are various conflicting attitudes towards and competing factors in the realisation and variation of postvocalic /r/ in SgE. Therefore, in order to get a clearer, more systematic picture of rhoticity in SgE, one needs to consider a combination of these factors, concurring with the view of Salbrina and Deterding (2010) that it would otherwise be a misinterpretation of the actual situation of emergent varieties. At this point, it should be noted that in addition to this more updated multidimensional approach to the analysis of rhoticity, and relatedly /r/ variation in general, in SgE, newer SgE data also needs to be collected. Findings of past studies done as discussed here either have been found 8 – 20 years ago or, although are from more recent studies, have been largely based on speech data from sources gathered over 10 years ago. For a young variety like SgE which is in a stage where changes are rapid and frequent, the collection of more current data is necessary in order for a clearer, more updated, and more valid picture and discussion of /r/ variation.

Regardless of variety, however, this r-ful/r-less divide is not always categorical and should be seen as a more gradient sort of phenomenon (Foulkes & Docherty, 2006:411). At the same time, in instances of non-rhoticity, variation and non-categorical patterns also occur in the phonological processes of /r/-sandhi.

2.4.2 Implications of non-rhoticity

/r/ in non-rhotic accents is not generally realised in pre-consonantal or pre-pausal conditions. However, when it is realised, 'it occurs as linking /r/ in etymologically r-ful words and as intrusive /r/ in etymological r-less words after non-high vowels and schwa' (Lawson, Stuart-Smith, et al., 2011) as mentioned in Section 2.3.1. This is reported to be substantially common in non-rhotic accents (Brown, 1991:98; Deterding & Poedjosoedarmo, 1998:138).

Although termed collectively as /r/-sandhi, both linking /r/ and intrusive /r/ evoke different attitudes towards them. Despite its widespread occurrence, the intrusive /r/ is regarded as 'incorrect', 'sub-standard' and 'objectionable' by some English speakers (Deterding & Poedjosoedarmo, 1998:138; Roach, 2000:144) and is 'often stigmatized and suppressed', for example in RP and middle-class NZ speech (Broadbent, 1991:282; Hay & Warren, 2002). A similar situation is reported in SgE by Tan (2012) where she claims that intrusive /r/ occurs independently of the linking /r/, and that it is 'in itself a social class marker' as she found that speakers who have the tendency to produce the intrusive /r/ are usually those with low education levels and socioeconomic status. It was also reported that these users of intrusive /r/ were also perceived, in an attitudinal test, as foreign, undesirable, unintelligent and of low education levels. This significant match between production and perception further substantiates, according to Tan (2012), the claims of negative associations with the intrusive /r/ in SgE.

Intrusive /r/ is, however, not always viewed negatively as found by Foulkes (1997) in a study of middle class Newcastle English. These speakers, although avoiding the use of intrusive /r/ in casual conversational speech, appeared to produce it in carefully read speech. It was hypothesised then that speakers were making conscious efforts to produce forms that were distinctly non-local and, as such, it was concluded that they deem the intrusive /r/ as 'prestigious or advantageous' (Foulkes, 1997:83–84).

2.4.3 Sociophonetic variation in /r/ realisation

Besides in the distribution of /r/, sociophonetic change and variation are also evident in various studies of English /r/ articulation. The findings of these studies focus largely on tongue shapes of underlying approximant /r/, mainly in the postvocalic or coda context (Scobbie, Lawson, Nakai, Cleland, & Stuart-Smith, 2015). Although much of the literature on both ScE and AmE report prevailing individual interspeaker variation, 'strongly systematic social variation in tongue shape for /r/' in ScE has been found (Scobbie et al., 2015). In the ScE context, variation in coda /r/ appears to be a strong index of social class; differing patterns can be observed between working- and middle-class speakers. Derhoticisation has been found to be indicative of working-class speech in Glasgow and Edinburgh which, also reported in early works (e.g. Romaine, 1978), has the tendency to have 'weaker acoustic correlates of rhoticity in coda position' (Dickson & Hall-Lew, 2017; Lawson, Scobbie, et al., 2011; Scobbie et al., 2015; Stuart-Smith, 2007). Derhoticisation, however, has been found to not be categorical and therefore studies have shown a need for gradient scales in the analysis of /r/ to account for the occurrence of weakened variants (e.g. derhoticised /r/) as well as intermediate ones (Dickson & Hall-Lew, 2017; Lawson et al., 2008).

Also linked with social class are taps and labial /r/ realisations. It is said to be characteristic of the upper-class RP speakers to realise /r/ as an alveolar tap [ɾ] when it exists intervocalically or following a dental fricative but this is rare in modern RP (Wells, 1982). The use of a labial variant of the approximant /r/ was formerly commonly associated with upper-class affectation (Wells, 1982:282), as depicted satirically in advertisements, film and literature (e.g. in *Monty Python's Life of Brian*, 1979, in George Orwell's *Keep the Aspidistra Flying*, 1936) (Foulkes & Docherty, 2000:32). Negative perceptions towards the labial /r/ realisation are also apparent in the other negative associations that it has been tagged with - childish, defective and even effeminate. This can probably be traced back to the first mentions of a variant of /r/ which closely resembles what is called today the labiodental approximant [ʋ]. This, according to Foulkes and Docherty (2000), was in an editorial note by Christmas, found in the third edition of Pegge's *Anecdotes of the English Language* (Pegge, 1844:66 in Jespersen, 1909:82). Although a specific phonetic symbol or quality was not stated, Christmas commented that due to being incapable of producing 'r', people use a 'w' in place of 'r' instead. This perception of the variant being a speech defect was subsequently reflected in influential works over the years (e.g. Cruttenden, 2008:29; Gimson, 1989:209).

The labiodental approximant [ʋ] has, however, gone through a change and is treated with a lot more acceptance nowadays. Although public figures, for example television personalities, musicians, sportsmen, actors and even government ministers, who are users of the labiodental approximant [ʋ] have been criticized and ridiculed for their labial /r/ realisation, the fact that they are seen/heard using the variant has also contributed to the widespread usage and acceptance of the variant (Foulkes & Docherty, 2000). At the same time, it also appears that school teachers and speech therapists no longer regard the use of the labiodental approximant [ʋ] as a 'speech-impediment' or inaccurate articulation as they once did, heightening the possibility that there are lesser social pressures for children to switch to a 'more adult pronunciation' and thus people subsequently find less need to acquire a more apical approximant variant (i.e. post-alveolar approximant [ɹ]) (Hughes et al., 2005:5). Although there are still stereotypical views of affectation, defective speech and/or infantilism, there is undoubtedly an increased frequency and widespread presence of the labiodental approximant [ʋ] which is 'now heard very frequently in the accents of a wide range of English cities' (Altendorf & Watt, 2008:212). It has become a well-established variant in Norwich where there is a significant increase in speakers using the labiodental approximant [ʋ] between two studies conducted 15 years apart (Trudgill, 1974, 1988). This labial variant is also reportedly slowly emerging as a widespread 'recent innovation in RP' (Cruttenden, 2008:81) and amongst younger speakers in Milton Keynes (Kerswill, 1996; Williams & Kerswill, 1999), Hull (Williams & Kerswill, 1999), Middlesborough (Llamas, 2001), Leeds (Carter & Local, 2007; Marsden, 2006), and Newcastle and Derby (Foulkes & Docherty, 2000). The exact reason for the existence of this variant, however, remains unknown. A contender is the process of accent-levelling with its roots set in the influences of Yiddish speakers from the London Jewish community in the late 1800s, Cockney, and Estuary English (Foulkes & Docherty, 2000; Wells, 1982). This idea of levelling is also echoed by Marsden (2006:168) who found that 'relatively diverse social network contacts rather than strong ties within a particular close-knit local network' was common for users of the labiodental approximant [ʋ] and the variant was, therefore, a result of them being in contact with individuals on a 'wider geographical level' and having to participate in 'levelling processes'.

Ethnic- and gender-determined variation have also been found in studies of /r/ realisation (e.g. labiodental approximant [ʋ] in SgE (Kwek, 2012) and trilled /r/ in IndE (Chand, 2010)). The labiodental approximant [ʋ] in SgE, as in BrE, has been found to be an emergent variant in studies involving young SgE speakers (Deterding, 2007; Kwek, 2012). At present, no cross-generational study has been carried out to ascertain empirical evidence for an age-effect on the use of this labial variant yet. However, it has been shown that the variant is used significantly more often by female than male speakers of SgE (Kwek, 2012). Preliminary studies have also suggested that there are differences in frequency of usage between ethnically Chinese and ethnically Malay SgE speakers, with the former being the more likely users (Kwek, 2015). Trills have been found to be used more frequently by students and retirees than by working adults in Chand's (2010) study on urban Indian English. It was also found that speakers living outside Delhi had a higher likelihood of displaying trills, suggesting regional or cross-linguistic effects. While further research needs to be done to further substantiate these claims, trills appear to be used more often by males, and have neither links to formality of speech or prestige (Chand, 2010).

Sociolinguistic studies of rhotics have thus shown the importance of considering how language external factors play a significant role in linguistic phenomenon, lending strong support to Foulkes and Docherty's (2006:411) claim that the patterns of linguistic behaviour are 'wholly the product of social construction' and are 'learned by speakers through the experience of using language in social interaction'.

2.5 Summary and key predictions

This chapter has provided a discussion of the relevant literature, covering concepts that are pertinent to the current study of /r/ variation in SgE. It also sets the stage for the exploration of the following hypotheses made in the attempt to answer the study's delineated research questions, as stated in Section 1.3:

1) A more realistic approach to studying /r/ realisations is the acknowledgement that there is likely a range of intermediate and/or incremental variants that exist on a continuum of sorts rather than just categorical extreme representations of the variants in question.
2) There are at least two variants of approximant /r/ in SgE that are potentially distinguishable, both auditorily and acoustically.
3) The various acoustic cues that should be considered in the analyses of approximant /r/ are namely patterns of F2, F3, F4, and F5, F2 and F3 transitions, and proximity between F2 and F3.
4) Some, or a combination of some, of the mentioned acoustic cues may be more applicable to the acoustic analyses of SgE /r/ variants than others.
5) There is highly likely variation within and between varieties of English in the relevance of acoustic cues that distinguish /r/ variants.
6) A more systematic, instead of the usual impressionistic, analysis of rhoticity and possibly also of taps and trills might be possible in SgE if the sample data is more inclusive of SgE speakers from different ethnic groups due to influences of linguistic environments/backgrounds.
7) /r/ variation in SgE could be conditioned by both linguistic and non-linguistic factors and can only be better understood if studies included more representative data.

8) The analysis of /r/ variation in SgE needs to adopt a multidimensional approach both in the acoustic investigation of /r/ variants and in the consideration of the effects of both linguistic and non-linguistic (i.e. social) factors.
9) Change in SgE /r/ is likely considering the patterns observed in varieties that have linguistically- and socially- similar environments.
10) There will be both similarities and differences in the acoustic features of /r/ variants and in /r/ variation found between SgE and other varieties of English.
11) The study of /r/ in SgE will potentially contribute further to the general study of /r/ in terms of acoustic features and relationships between variants, also the changing 'face of /r/ in varieties of English.

Chapter Three

Data and Methods

Speaker and data collection details are presented first, with reasons for the choice of speaker profiles and types of materials given. A description of the procedures for data collection and details of the recording process will then follow. Methods of segmentation and categorisation of data according to phonological environments will be explained, leading to a discussion of methods used in the auditory categorisation and acoustic measurement exercises.

3.1 Speakers and Data Collection

3.1.1 Profile of speakers

To ensure a more valid, generalisable account of spoken SgE, this study includes data collected from 104 SgE speakers belonging to the four main ethnic groups (i.e. Chinese, Eurasian, Malay, Indian) in Singapore. Recruitment of speakers was done both in Singapore and in Cambridge, UK. The breakdown of speakers per ethnic group, speaker sex, and location is as follows:

Table 3.1: Number of speakers according to ethnic group, speaker sex, and location of recruitment/recording.

	Singapore		Cambridge, UK		Total	
	Female	Male	Female	Male	Female	Male
Ethnically Chinese	19	19	6	6	25	25
Ethnically Malay	16	6	1	1	17	7
Ethnically Indian	9	5	1	0	10	5
Ethnically Eurasian	10	5	0	0	10	5
Total	54	35	8	7	62	42
	89		15		104	

SgE speakers recruited from Cambridge, UK are students at the University of Cambridge and were included in the study to test for the effects of recording location. They also served as representatives for SgE speakers who are, at the point of recording, studying and living outside of Singapore - this social profile is relatively common amongst Singaporeans. Upon initial impressionistic analyses, it was found that the location of recruitment and recording, and this particular social profile were not factors to be considered in further analyses as they did not affect /r/ variation in SgE.

All speakers in this study were between the ages of 17 and 54 years old at the point of data collection. The initial intention was to obtain a balanced sample size per age group (i.e. lower, middle, upper) in order to enable an analysis of cross-generational patterns in SgE /r/ realisation - there is paucity in this area of research in SgE although herein lies potential contributions to the understanding of variation and change in SgE. However, during the process of data collection, recruitment of speakers from the older age group (i.e. 50 years and above) revealed to be challenging for various reasons. An outstanding constraint was the fact that older SgE speakers had wide ranges of linguistic repertoires and language proficiencies that contributed more variables than desirable for valid and reliable analyses. Resultantly, the majority of speakers recorded were between 20 and 40 years old. This age group bears more similarities to that of earlier related studies (Kwek, 2005, 2012) and, while variation in a range of social factors is present, there is more homogeneity in its speakers' linguistic abilities, therefore allowing for reliable comparisons. Although the initial intention of cross-generational comparisons could not be materialised, the smaller groups of SgE speakers, aged under 20 years old and over 40 years old, nonetheless facilitated in enabling a preliminary look at not only variation but also change in /r/ realisations in spoken SgE (see Sections 4.2 and 6.3.2 for details).

It was ensured that all speakers had received formal education in the bilingual education system of Singapore at the pre-primary, primary and secondary levels (see Section 1.1.2 for a brief account of the Singapore bilingual education system). At the point of data collection, they were either undergraduates or graduates at the tertiary level (i.e. diploma/degree level); some of the latter group had also obtained or were, at that point of time, pursuing a higher degree (i.e. Master/Doctorate) in their respective fields of specialisation. It has been hypothesised that Singaporeans belonging to this education level have higher levels of English language proficiency which gives them the ability as well as opportunities to make informed choices on the use of different varieties of English, varying according to the level of formality and appropriacy a situation calls for (Pakir, 1991). This therefore, makes them representative of the form of spoken SgE that the study focuses on as described in Section 1.1.3. Additionally, it has been shown in earlier research that speakers in the 20-40 age group are more likely to be users of an emergent /r/ variant, the labiodental approximant [ʋ] (Foulkes & Docherty, 2000; Kwek, 2005). For these reasons, speakers of this profile were chosen for this investigation of /r/ variation in spoken SgE.

Before the start of any data collection, all speakers were sent a letter of invitation to participate. This included brief descriptions of the study and procedures of data collection. Extra care was taken not to disclose details on the study to prevent any potential unreliability of data collected. To ensure that speakers participated voluntarily and that informed consent was attained, they were requested to fill in an 'Acknowledgement of Consent' which is an ethics requirement of the Department of Theoretical and Applied Linguistics at the University of Cambridge and can be found in Appendix A. They were also assured that absolute confidentiality and anonymity would be ensured in all forms of presentations and reporting of data and results.

Other personal and language background details were collected through the 'Participant's Information Sheet' (see Appendix B) which was administered after the data collection exercise was completed. Speakers were asked to provide personal details - their parents' ethnicity, their occupations, the names of schools they have attended/are attending and, if applicable, a list of countries in which they have lived as well as the number of years of living abroad. Other language background details collected consist of languages and dialects spoken, the starting ages at which these were used as well as their conversational partners. Personal opinions of their dominant language, most proficient language, as well as language of choice, together with information on interactions with speakers of other varieties of English were also obtained. These help to ensure the availability of a clearer description of speaker profiles and language backgrounds, with which a more detailed and complete picture of /r/ variation of spoken SgE can be discussed.

3.1.2 Labelling of speakers

To facilitate anonymity, throughout the course of this study, speakers involved are labelled according to three factors – ethnicity, speaker sex and subject number. Thus, 'e' symbolizes an ethnically Eurasian SgE speaker, 'f' is used to represent a female speaker, and numbers (e.g. 3) differentiate the speakers within their speaker-sex groups. Therefore, Speaker ef3 is the third SgE speaker in the ethnically Eurasian female sub-group.

3.1.3 Materials and elicitation

Data from two speech styles were collected for this study – read and conversational speech. The main goal of collecting read speech data is to provide insights into the production of careful and deliberate speech which can be taken to simulate a more formal register. Read speech data were collected through three different read speech materials, namely a short passage, a set of structured sentences and a word-list (see Appendix C for full copies of these read speech materials).

The short passage is that of "The Boy Who Cried Wolf" which was adapted by Deterding (2006). Stylistically, the passage serves to elicit a form of deliberate and formal speech that would be expected from the reading of a set text yet provide a context of continuous utterances which is more representative of natural speech production. The choice to use this passage instead of the more traditionally-used "The North Wind and the Sun" was based on the fact that the latter possesses some inherent weakness as highlighted by Deterding (2006). More importantly, the 'wolf' passage includes all possible phonological environments in which /r/ would occur in the English language.

The second source of read speech materials was formulated in the attempt to ensure that a larger set of similar tokens was collected from all subjects and that different linguistic factors that were to be investigated could be included since it was difficult to exercise this sort of control in tokens collected from the passage and from conversational speech. A set of 53 structured sentences was thus carefully constructed for these purposes. These sentences are of varying lengths and content, and included dummy sentences to minimize predictability effects. As with the 'wolf' passage, they account for all phonological environment possibilities. Additionally, as these sentences elicit connected speech, factors like word and sentence stress as well as the phenomena of linking /r/ and intrusive /r/ were taken into account in the sentence construction process.

Read speech data was also collected from a third source of read speech materials. This consists of a list of 34 words in the carrier phrase 'Please say *X* again'. It includes tokens of /r/ in the various phonological environments, respective minimal pairs involving tokens of /l/, /w/ and /v/ (e.g. *rail ~ wail, berry ~ belly, real ~ veal*), and dummy tokens. These were arranged in a randomized order. The structured carrier phrase encourages a situation where all surrounding sounds and stress patterns are kept relatively constant in the attempt to regulate possible coarticulatory effects. However, it is acknowledged that this is, eventually, dependent on individual speakers and there was a conscious effort to consider such variation in the analysis process.

To provide a more encompassing description of spoken SgE, conversational speech data was also included in this study. This was collected through approximately 15- to 25-minute conversations that speakers had with the researcher. These started with a conversational prompt of describing a most memorable holiday experience and usually extended to other holiday experiences and leisure activities. This topic was chosen to encourage a less formal spontaneous environment, aimed at eliciting conversational speech produced in a more casual and relaxed setting.

3.1.4 Recording Conditions and Procedures

Data was collected through recording sessions that involved speakers reading the three sets of read speech materials as well as participating in a conversation with the researcher, as described above. Each recording session, lasting a total of about 40 minutes to an hour, was carried out with each of the speakers individually. Recordings were done either in Singapore or in Cambridge, UK. As it was important that the speakers felt comfortable with the setting in which the recordings took place, they were asked to decide on an indoor location that suited them best. Although most of the time recordings were done in quiet environments, there were the occasional disruptions caused by ambient noises. However, this did not greatly affect the quality of the recordings. The parts of the recordings which were affected were excluded from the analyses.

During the recording, two portable digital recorders (ZOOM H4n/ZOOM H1 Handy Recorder) were placed a few inches away from the speaker's mouth and his/her voice was captured directly in the .wav format without compression. Speech was recorded directly as digital rather than analog signal, ensuring lower noise level and higher quality recordings. Sampling rate was set at a level of at least 44,100Hz/16 bit as a frequent baseline level requirement for close acoustic analysis of speech is one that is of at least 22,500 Hz for good sound quality (Hayward, 2000). Speakers were asked to speak in a way that made them most comfortable and that they felt best represented them as speakers of the English language. They were also informed that they had the option of self-correcting if they made a mistake.

3.2 Segmentation and categorisation of /r/ tokens

Conversational speech data for all speakers was transcribed orthographically by hand and, together with the read speech data collected, was forced-aligned using the FAVE-align program in the FAVE Program Suite (Rosenfelder, Fruehwald, Evanini, & Yuan, 2011). This forced-alignment converts orthography to phones and also auto-segments both words and phones. A Praat TextGrid was then returned with both a word tier and a phone tier for every speaker. This output was checked using Praat Version 6.0.07 (Boersma & Weenink, 2015) and inaccurate alignments were corrected manually. All tokens of /r/ were then identified and categorised according to linguistic factors (i.e. phonological position, word class and following context), and non-linguistic factors (i.e. speech style, age, speaker sex, and ethnicity). Details of the levels within phonological position and following context are presented below.

An earlier study on the /r/ in spoken SgE (Kwek, 2012) focused on the labiodental approximant [ʋ] and post-alveolar approximant [ɹ] in four phonological positions – word-/syllable-initial, word-/syllable-initial consonant clusters, intervocalic, and prevocalic word-final (linking /r/). Although SgE is known to be generally non-rhotic and does not have /r/

realised in all word-final positions (Trudgill & Hannah, 1994), the fourth was included as it was hypothesised that in the case of connected speech, it was common for speakers of non-rhotic varieties to display the linking /r/ when a word-final /r/ precedes a vowel. However, no conclusions for linking /r/ could be made in that study due to its low frequency of occurrence. Following Kwek (2012), the current study also analyses /r/ in the same 'non-final' positions. Additionally, in order to have a more complete picture of phonological effects on /r/ variation in SgE, all the other 'final' positions are included as well. It should be noted that the designation of this 'syllable-final' term refers to the underlying position of /r/. Trying to determine, for example, which syllable the 'linking sound' is articulated in will be difficult and subject to theoretical considerations which goes beyond the scope of the current study. This might be taken up, however, as a separate study in the continual study of /r/ in SgE. The terms for the phonological positions were fine-tuned and more specific details of what each comprises are as stated:

- Syllable-initial
  - word-boundary; preceded with a consonant, a vowel, or a pause
    (e.g. *(the)* ***r****ain*, *(not)* ***r****eally*, *(#)* ***r****aising*)
  - word-internal; preceded with a consonant (e.g. *al****r****eady*)

- Syllable-initial consonant cluster
  - word-boundary (e.g. ***cr****owd*)
  - word-internal (e.g. *hun****gr****y*)

- Intervocalic
  - morpheme-internal (e.g. *so****rr****y*)
  - morpheme-boundary (e.g. *loite****r****ing*)

- Syllable-final non-prevocalic
  - word-boundary; followed by a consonant or a pause (e.g. *popula****r*** *(that)*, *poste****r*** *(#)*)
  - word-internal; followed by a consonant (e.g. *pe****r****fect*)

- Syllable-final consonant cluster
  - word-boundary (e.g. *pa**rk***)
  - word-internal (e.g. *apa**rt**ment*)

- Syllable-final prevocalic
  - word-boundary (linking /r/) (e.g. *bothe**r** (us)*)

- Intrusive /r/
  - word-boundary (e.g. *Asia**(r)**and*)
  - morpheme-boundary (e.g. *draw**(r)**ing*)

Each identified /r/ token was categorised under one of the seven categories listed above. The first three phonological positions (i.e. syllable-initial, syllable-initial consonant cluster, and intervocalic) are also collectively termed as non-syllable-final positions in the analyses and discussions that follow, and the next four are referred to as syllable-final positions.

In addition to the categorisation of phonological positions, following contexts were also determined for each of the tokens of /r/. They were broadly categorised into the following 13 levels – high front (i.e. /ɪ/, /iː/, /e/, /ɪə/, /eɪ/), low front (i.e. /ɛ/, /æ/), mid-central (i.e. /ə/, /ɜː/), low back unrounded (i.e. /ʌ/, /ɑː/, /ɑɪ/, /ɑʊ/, low back rounded (i.e./ɒ/, /ɔ/, /ɔː/, /ɔɪ/), and high back (i.e. /ʊ/, /uː/, /o/, /oː/, /ʊə/) for vowels (6 levels); affricate (i.e. /tʃ/, /dʒ/), fricative (i.e. /f/, /v/, /θ/, /ð/, /s/, /z/, /ʃ/, /ʒ/, /h/), glide (i.e. /j/, /w/), liquid (i.e. /r/, /l/), nasal (i.e. /m/, /n/, /ŋ/), and stop (i.e. /p/, /b/, /t/, /d/, /k/, /g/, /ʔ/) for consonants (6 levels); pause for when the /r/ token is in a word-boundary pre-pausal position (1 level). Preceding context was excluded from this analysis and thus not specified for all tokens of /r/.

3.3 Auditory categorisation

Based on an initial casual listening of the speech data collected, it seemed natural for SgE speakers to produce more than one /r/ variant. They were also heard to have a range of intermediate variants and therefore a 'binary scoring of variants is inappropriate' (Foulkes & Docherty, 2000:410). Foulkes and Docherty (2000) found a similar situation with the speakers of their study and therefore created a 'sociolinguistic index' to 'quantify the degree of [ʋ] usage' in their speakers. As mentioned in Section 2.1.2, the applicability of accounting for a range of intermediate and/or incremental variants can also be seen in the categorical scale representing a continuum of rhotic strength, which was modified from that of Delattre and Foreman's (1968), used by Lawson, Scobbie, and Stuart-Smith (2011) in an auditory classification exercise carried out to show the patterns of auditory variation in postvocalic /r/ for gender and class in ScE. This scale was subsequently adapted and used by Dickson and Hall-Lew (2017) to study rhoticity differences in ScE speakers in Edinburgh who have had a change in socioeconomic status through retirement. As many similarities between these studies and the sociophonetic nature of the current study on /r/ variation in SgE were identified and also agreeing with the practicality of acknowledging intermediate variants, the mentioned scales were adapted for this study and a perceptual strength index applicable to /r/ realisations in SgE was devised. This index is a six-point ordered nominal scale (see Figure 3.1) on which all /r/ tokens were rated according to an auditory perception of strength. It includes the following categories - 'null realisation ∅' for when no /r/ is realised, 'weak labiodental approximant [ʋ]' and 'strong labiodental approximant [ʋ]' as the weak and strong realisations of the labial /r/, 'weak post-alveolar approximant [ɹ]' and 'strong post-alveolar approximant [ɹ]' as the weak and strong realisations of the typical 'English /r/', and 'tap [ɾ]/trill [r]' for realisations that require some sort of contact/strike at the alveolar ridge which causes a distinct disruption to the acoustic signal. Tap [ɾ] and trill [r] have been combined into a single category as no previous research has been done to identify the true articulation of the sound in SgE.

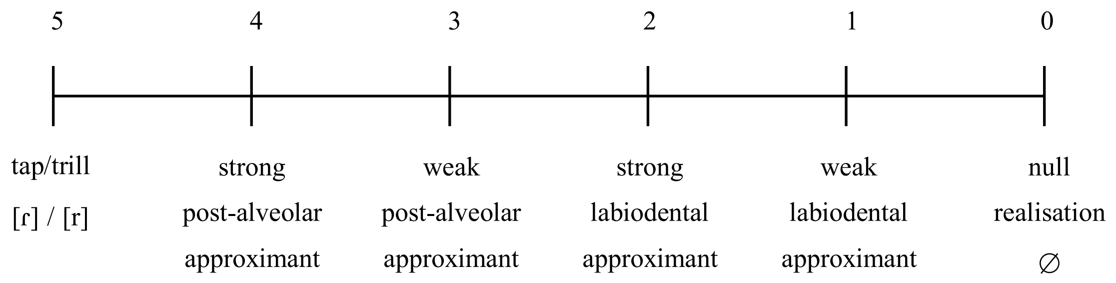

Figure 3.1: Perceptual strength index of /r/ variants in Singapore English.

It is acknowledged that this representation of a continuum is in some ways contentious. Including taps/trills alongside approximants is conceptually challenging because of the articulatory differences in the place and manner of their realisations which in turn results in ambiguity of what determines the 'strength' of /r/ on which the index is based. However, following the practice of Lawson, Scobbie, and Stuart-Smith (2011) and, more importantly, due to the fact that these /r/ variants are used interchangeably in various phonological environments in SgE, including all /r/ variants in this index which represents a continuum of 'perceptual strength' was found to be the most appropriate in enabling a complete analysis and cohesive picture of /r/ variation in SgE. 'Perceptual strength' here is taken to refer to the level of disruption there is on the acoustic signal rather than as a reference to the extent of articulatory actions and/or efforts taken to realise the /r/ or how strong the perception of an /r/ realisation is to the listener (i.e. how clearly the listener hears an /r/). Therefore, a tap [ɾ]/trill [r] is at the highest end of this continuum (i.e. Score 5) as it has the strongest disruption of the acoustic signal while, as there is no disruption of the acoustic signal in a null realisation ∅, it is on the lowest end (i.e. Score 0). Also, it should be further clarified that, although partly adopted from Foulkes and Docherty (2000), the index used in this current study on SgE /r/ differs from theirs particularly in the fact that their index assumes weak variants of the post-alveolar approximant [ɹ] and the labiodental approximant [ʋ] to become more alike as they move towards each other on the continuum. This study's index, however, delineates a weak post-alveolar approximant [ɹ] as the transition from a clear distinct post-alveolar approximant [ɹ] to a clear distinct labiodental approximant [ʋ] and a weak labiodental approximant [ʋ] as the variant that is in the process of losing any characteristic of a rhotic, moving closer to being a null realisation.

It should be noted that care was taken to ensure that all /r/ tokens analysed were taken from sections of speech that were relatively unmarked, minimizing possible effects from other features of speech (e.g. creak, unusually high pitch, onomatopoeia, imitation of other accents, etc.). A neat categorisation was not always possible and, in the case of read speech data, there were also occasionally situations where stipulated words consisting of /r/ tokens in the set texts were unclear, mispronounced or omitted by the speaker. Whenever these happened, the /r/ tokens were labelled as 'unidentifiable' and left out of the analyses.

Auditory rating was done by the researcher, who is a native SgE speaker, on all /r/ tokens in the data collected. To ensure inter-rater reliability, auditory rating was also carried out on 50% of the /r/ tokens by a second rater who is also a native SgE speaker and has had experience in conducting Phonetics and Phonology analysis and research. This was 'randomly, but evenly, sampled across all experimental conditions' as suggested by Clopper (2011:195) and yielded an 85% agreement level. Re-rating of the 15% was done and in instances where agreement could not be reached even after a discussion between raters, the tokens were excluded. Also, on two additional separate occasions of about two or three months after the initial rating and apart from each other, re-ratings of 50% of all the /r/ tokens was done by the researcher to ensure intra-rater reliability. This was also randomly sampled and returned a 92% and 93% agreement rate respectively. For both instances, a re-listening of the /r/ tokens that failed to obtain agreement was done and should no agreement be reached, the token was excluded.

3.4 Acoustic measurements

Acoustic analyses were done to further validate the auditory categorisation of approximant /r/ variants in SgE (i.e. Scores 1 – 4 in the perceptual strength index, see Figure 3.1) and also qualify the differences between and within the perceptually strong approximant /r/ variants through acoustic measures. Only tokens of /r/ which were categorised as Scores 1 – 4 in the perceptual strength index were analysed acoustically.

All acoustic measurements were done by hand using Praat (Version 6.0.07), a free speech analysis software produced at the University of Amsterdam (Boersma & Weenink, 2015). To ensure a perceptually realistic scale of frequency, all measurements were converted from Hertz to the auditory Bark scale, using the formula suggested by Traunmüller (1990), where (f) is the frequency in Hertz and (z) the frequency in Bark:

$$z = [\ 26.81 f\ /\ (\ 1960 + f\ )\ ] - 0.53$$

Although there has been much debate about the sole reliance on a lowered F3 as an indicator of an /r/ due to its multifaceted nature, there is evidence from previous findings

(Foulkes & Docherty, 2000; Kwek, 2012) that F3 is expected to be of a lower frequency for the post-alveolar approximant [ɹ] than for the labiodental approximant [ʋ]. This study will therefore continue to analyse variation in F3 between the two approximant /r/ variants. Nonetheless, F3 will not be singularly used in the discussion of acoustic variation in approximant /r/. Since for the post-alveolar approximant [ɹ], as reviewed in Chapter Two, a low F3 is usually accompanied by a lowered F2 (Hayward, 2000; Scobbie, 2006) and there is a close proximity between F2 and F3 (Heselwood, 2009; Jones, 2005), measurements of F2, in addition to F3, were also made and the distances between F2 and F3 (henceforth, F3-F2 distance) were subsequently calculated. Moreover, F3-F2 distance has been posited to be an important cue for perceptual retroflexion (Dalcher, Knight, & Jones, 2008) as a low F3, which should signal a post-alveolar approximant [ɹ], may not necessarily do so if F2 is very low. This further demonstrates the need to consider both F2 and F3 height, and thus, F3-F2 distance as well. Following Lawson, Stuart-Smith, Scobbie, Yaeger-Dror, and Maclagan (2011:79), measurements of F2 and F3 were taken at the midpoint of the steady state, whenever possible, but more particularly where there is an observable drop in amplitude which is ‘due to the added approximant articulation’. Figure 3.2 illustrates the measurements of F2 and F3.

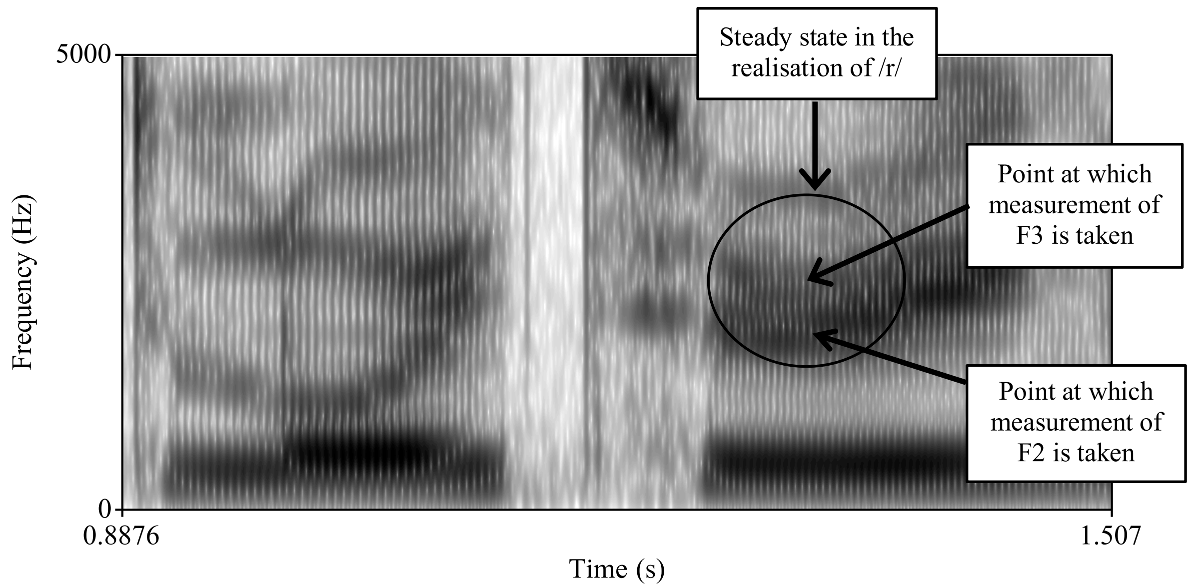

Figure 3.2: Points of F2 and F3 measurements for the realisation of post-alveolar approximant [ɹ] in ‘*loitering*’.

In addition, acoustic differences were found between the two approximant /r/ variants also by analysing ‘F3 rise’, which was defined as the difference between F3 peak and nadir, in an earlier study of the labiodental /r/ in SgE (Kwek, 2012). F3 nadir being the lowest point of the third formant in the /r/ realisation and F3 peak being the highest point. F3 rise was found to be indicative of the degree of retroflexion in the approximant /r/; the post-alveolar approximant [ɹ] has a steeper F3 rise than the labiodental approximant [ʋ], the latter lacks a distinct F3 rise (Kwek, 2012). Therefore, adapting that, the transition of F3 (i.e. the difference between F3 of /r/ segment and F3 of following vowel segment; henceforth, F3 transition) from /r/ into the following segment was calculated. It is acknowledged, however, that this will be affected by the type of vowel that follows /r/ so care must be taken in the interpretation of the results.

Slight lip-rounding is another feature of the approximant /r/ realisation (Cruttenden, 2014:30). The labiodental approximant [ʋ], however, has more defined lip-rounding and is therefore seen to have a lowered F2 (Dalcher et al., 2008). Relatedly, further acoustic investigation reported overlaps in terms of articulation of the labial-velar approximant [w] and the labiodental fricative [v] with the post-alveolar approximant [ɹ] and labiodental approximant [ʋ] (Dalcher et al., 2008) while labiodental approximant [ʋ] has been shown to have F2 formant patterns that are similar to those of the labial-velar approximant [w] and the labiodental fricative [v] (Kwek, 2012). Therefore, as done for F3 transition, the transition of F2 (i.e. the difference between F2 of /r/ segment and F2 of following vowel segment; henceforth, F2 transition) from /r/ into the following segment was also calculated (see Figure 3.3 for illustration of measurement points for the calculation of F2 and F3 transitions). Again, the type of vowel that follows /r/ could have implications on the results and should therefore be considered when interpreting findings. Although F4 has been posited to be a potentially useful acoustic cue, it has not been measured in this study. This is due to the nature of data collection for such a sociophonetic study (i.e. material collected in the field). It therefore meant that, unlike laboratory material, the quality of the audio recordings obtained was not always optimum for measurements of higher formant frequencies. Nevertheless, it remains a consideration for future further research in the study of /r/ in SgE.

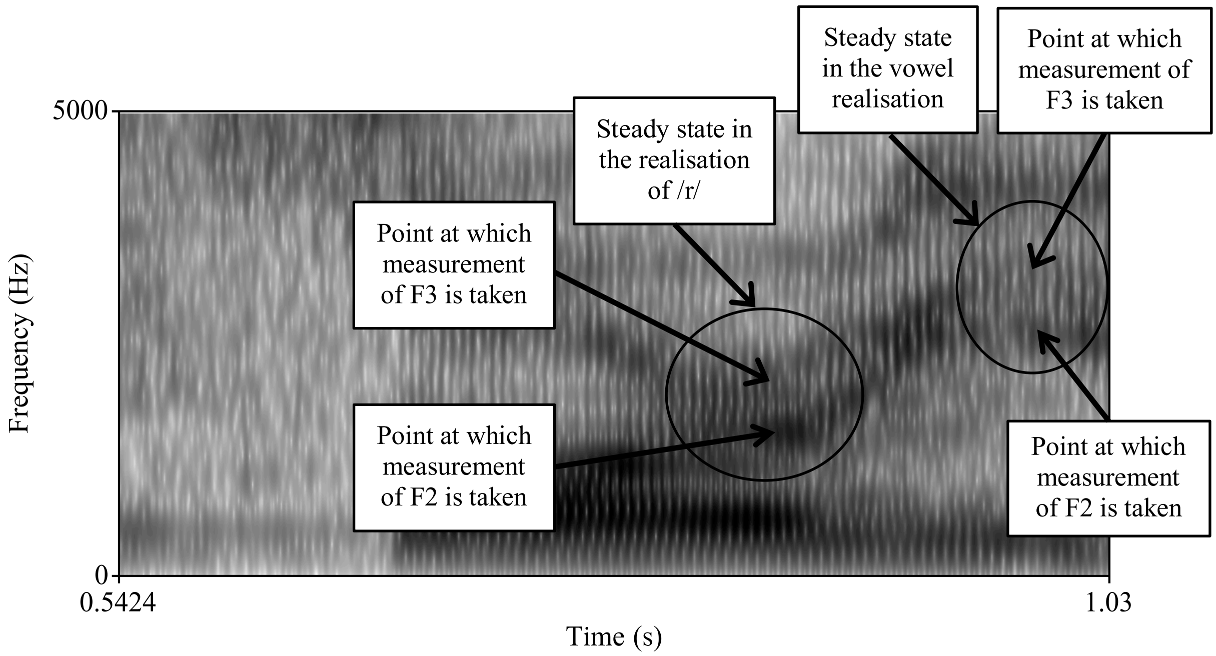

Figure 3.3: Points of F2 and F3 measurements for the realisations of post-alveolar approximant [ɹ] and following vowel segment from which F2 and F3 transitions are calculated in '*sorry*'.

This chapter not only describes the types of speakers and data, and methods of categorisation and measurement of /r/ used in the study, but also presents the rationales for the choices made for these, as well as the efforts taken at ensuring the validity and reliability of the processes of data collection and analyses. A deeper understanding of the related studies and concepts presented in Chapter Two with the clear picture of the data and methods of the study given here thus enables a more focused analysis of /r/ variation in SgE as presented in the next two chapters.

Chapter Four

Auditory Analysis and Results

Results from the auditory analysis of /r/ in SgE are presented in this chapter. This analysis of /r/ variants from both read and conversational speech data was done in two parts. The first consisted of the categorisation of /r/ tokens according to linguistic factors (i.e. phonological position, word class, following context) and non-linguistic factors (i.e. speech style, age, speaker sex, ethnicity), details as described in Sections 3.1 and 3.2, and an auditory categorisation exercise in which /r/ tokens were rated on a six-point ordered nominal scale that is based on the perceptual strength of /r/. This scale was adapted from the ones used by Foulkes and Docherty (2000) in their study of labiodental /r/ in Derby and Newcastle, and by Lawson et al. (2011) to describe postvocalic /r/ in ScE (see Section 3.3). The second part involved the statistical testing of results obtained from the auditory categorisation exercise. This chapter first gives a general overview of the variants of /r/ found in the data analysed and a summary of results from the descriptive statistical analyses done before presenting a detailed account of the considerations and motivations of statistics model choices. These are then followed by a presentation of statistical evidence of the effects of linguistic and non-linguistic factors on /r/ realisations in SgE.

4.1 General overview of data

Tables 4.1 – 4.5 collectively present an overview of the data according to linguistic factors (i.e. phonological position, word class) and speech style. As auditory categorisation was not always possible (see Section 3.3 for details), 29 out of the original 42,264 tokens were excluded in the final analysis. The final auditory analysis therefore consisted of a total of 42,235 /r/ tokens. The breakdown of the profile of speakers and the final number of /r/ tokens in the various subgroups is as shown.

Table 4.1: Number of speakers and /r/ tokens for each subgroup; read speech data (*n* speakers = 104, *n* /r/ tokens = 24,090).

Ethnicity	Speaker sex	*n* Speakers	*n* /r/ tokens	Read speech type
Chinese	Female	25	1150	passage
			3901	sentence set
			424	word list set
	Male	25	1147	passage
			4159	sentence set
			425	word list set
Eurasian	Female	10	460	passage
			1752	sentence set
			170	word list set
	Male	5	230	passage
			919	sentence set
			85	word list set
Malay	Female	17	779	passage
			2775	sentence set
			289	word list set
	Male	7	319	passage
			1287	sentence set
			119	word list set
Indian	Female	10	458	passage
			1840	sentence set
			170	word list set
	Male	5	230	passage
			917	sentence set
			85	word list set

Table 4.2: Number of speakers and /r/ tokens for each subgroup; conversational speech data (*n* speakers = 60, *n* /r/ tokens = 18,145).

Ethnicity	Speaker sex	*n* Speakers	*n* /r/ tokens
Chinese	Female	10	2755
	Male	5	1043
Eurasian	Female	10	3027
	Male	5	1985
Malay	Female	10	2769
	Male	5	1558
Indian	Female	10	3206
	Male	5	1802

Table 4.3: Number of /r/ tokens for each phonological position, according to speech style (*n* speakers = 104, *n* /r/ tokens = 42,235).

Speech style	Syllable-initial	Syllable-initial consonant cluster	Intervocalic	Syllable-final
Reading	3658	4526	1817	14,089
Conversation	1975	3698	2212	10,260

Table 4.4: Number of /r/ tokens for each syllable-final position type, according to speech style (*n* speakers = 104, *n* /r/ tokens = 24,349).

Speech style	Syllable-final non-prevocalic	Syllable-final consonant cluster	Syllable-final prevocalic (word boundary)	Intrusive /r/
Reading	7164	3439	3070	416
Conversation	6436	2125	1628	71

Table 4.5: Number of /r/ tokens for each word class, according to speech style (*n* speakers = 104, *n* /r/ tokens = 42,235).

Speech style	**Content word**	**Function word**	**Not applicable (Intrusive /r/)**
Reading	17,711	5963	416
Conversation	10,798	7276	71

4.2 Overview of /r/ realisations and variation in Singapore English

The auditory analysis involved the rating of all /r/ tokens on a six-point ordered nominal scale. This scale is presented again, in Figure 4.1, for ease of reference. Scores 5 – 0 and their respective labels (i.e. tap/trill, strong post-alveolar, weak post-alveolar, strong labiodental, weak labiodental, null realisation) are used interchangeably in figures presented hereafter.

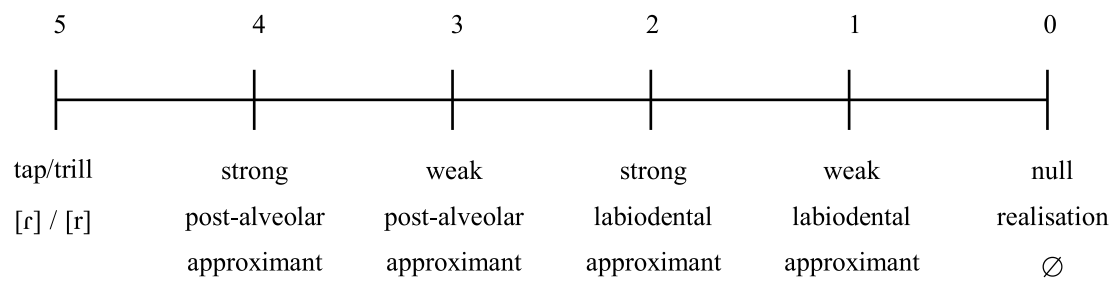

Figure 4.1: Perceptual strength index of /r/ variants in Singapore English.

Descriptive statistical analyses were initially done on both read and conversational speech data to provide a general picture of the variants of /r/ present as well as their distribution. What follows is an overview of the patterns of /r/ variation in SgE based on impressionistic hypothesis generations derived from the analyses of graphical representations. This sets the basis for more rigorous statistical analyses which will provide evidence for the variation. Figure 4.2 shows the variants of /r/ found in both non-syllable-final and syllable-final positions in both speech styles (i.e. reading, conversation). SgE speakers are found to display mostly null realisations (i.e. Score 0) and strong post-alveolar approximants (i.e.

Score 4), and a much lower percentage of strong labiodental approximants (i.e. Score 2) and weak post-alveolar approximants (i.e. Score 3) in both reading and conversation. The frequency of occurrences of /r/ variants within both speech styles pattern relatively similarly, with the exception of weak labiodental approximants (i.e. Score 1) and taps/trills (i.e. Score 5) where the former is the least commonly found variant in conversation and the latter in reading.

From this illustration of raw frequency data, it appears that a disproportionately large percentage of /r/ tokens in both reading and conversation are null realisations (i.e. Score 0). However, this suggestion that /r/ is mostly elided in SgE needs to be qualified through further analysis of other confounding variables (e.g. phonological position). A general overview of the frequency of occurrences of /r/ variants between non-syllable-final and syllable-final positions highlights the need for this qualification. As seen in Figure 4.3, when only non-syllable-final positions are considered, the number of null realisations (i.e. Score 0) drops drastically, proving that the high percentage of null realisations (i.e. Score 0) in Figure 4.2 is a result of /r/ tokens in syllable-final positions.

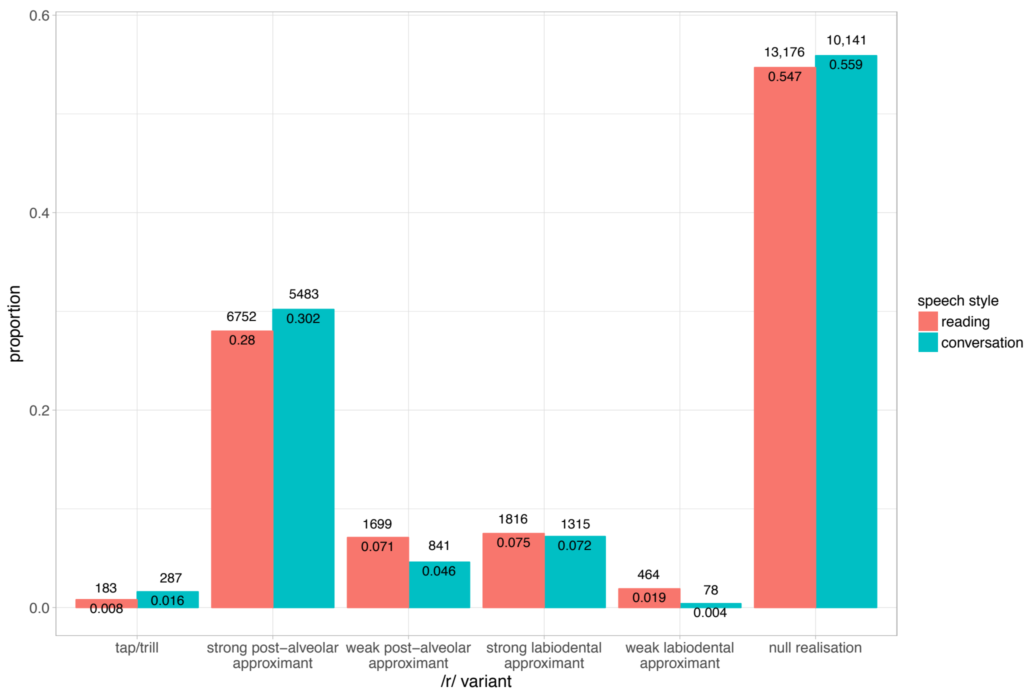

Figure 4.2: Variants of /r/ (left to right – Scores 5 – 0) in read (*n* = 24,090) and conversational speech (*n* = 18,145); all phonological positions. Numbers above the bars refer to raw frequency counts and numbers within the bars are the corresponding proportions (Proportions are calculated within speech style, e.g. all scores from reading add up to proportion unit 1.0/100%).

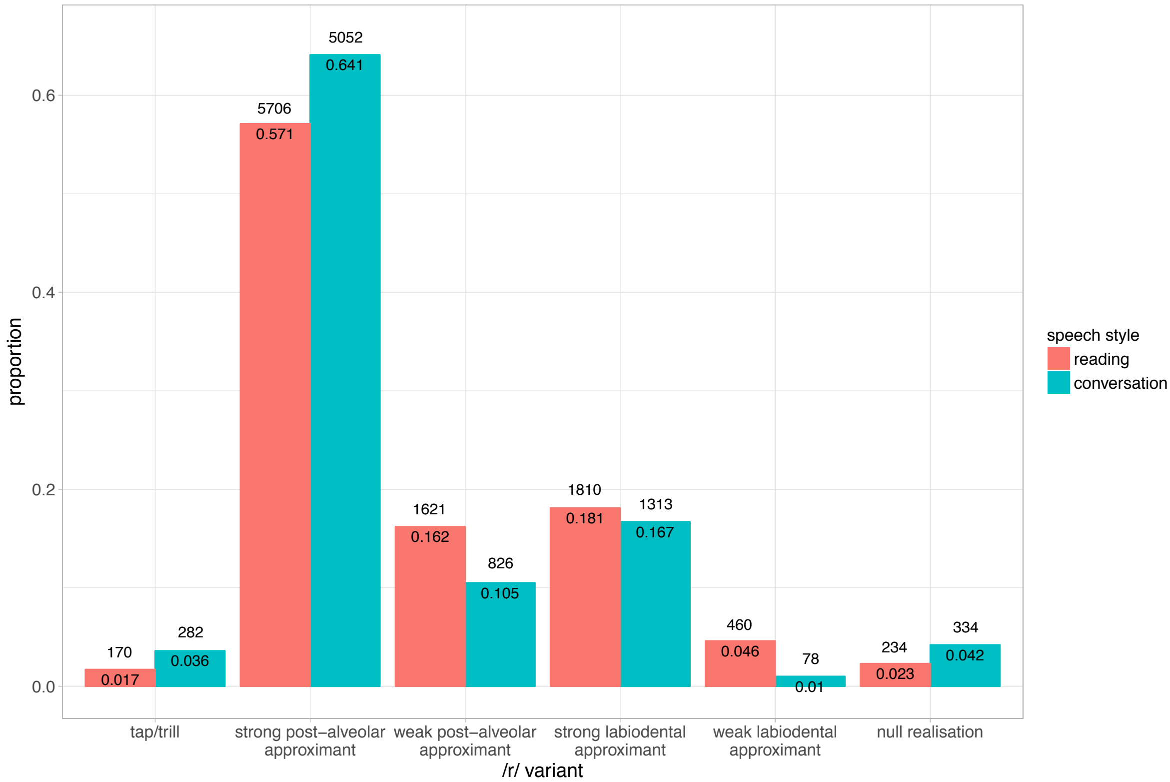

Figure 4.3: Variants of /r/ (left to right – Scores 5 – 0) in reading (*n* = 10,001) and conversation (*n* = 7885); non-syllable-final positions only. Numbers above the bars refer to raw frequency counts and numbers within the bars are the corresponding proportions, (proportions are calculated within speech style, e.g. all scores from reading add up to proportion unit 1.0/100%).

This is of little surprise as SgE is widely known to be a non-rhotic accent in which syllable-final /r/ is not realised (e.g. Deterding, 2007). However, to claim that syllable-final /r/ realisation is categorically absent in SgE would be incorrect; syllable-final /r/ exists in SgE. There also appears to be some levels of variation in /r/ realisations amongst the different syllable-final positions as illustrated in Figure 4.4.

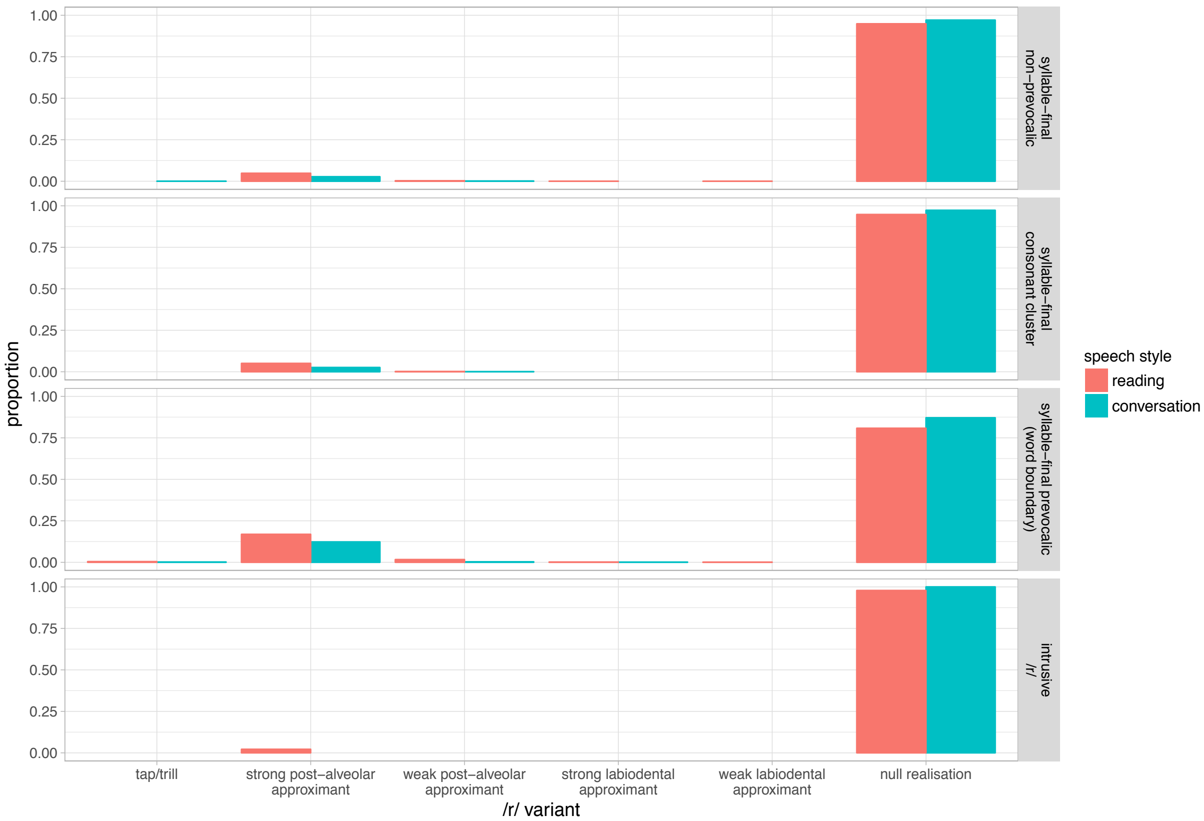

Figure 4.4: Variants of /r/ (left to right – Scores 5 – 0) in reading (*n* = 14,089) and conversation (*n* = 10,260); syllable-final positions only (presented in four rows: top to bottom – syllable-final non-prevocalic, syllable-final consonant cluster, syllable-final prevocalic (word boundary), intrusive /r/), (proportions are calculated within phonological position and speech style, e.g. all scores from intrusive /r/ in reading add up to proportion unit 1.0/100%).

From Figure 4.4, it can be seen that when /r/ does appear in syllable-final positions in SgE, it is most likely a post-alveolar approximant, and more commonly a strong realisation (i.e. Score 4) of that /r/ variant. There are also occasional realisations of the other /r/ variants in syllable-final positions. The two /r/-sandhi phenomena, linking /r/ (i.e. syllable-final prevocalic (word boundary)) and intrusive /r/, pattern very differently in terms of frequency of occurrence as well as realisation. Intrusive /r/ (e.g. *Asia**(r)**and*) occurs very rarely and only in reading, and, when it does, it is only realised as a strong post-alveolar approximant (i.e. Score 4). As only nine out of 487 instances of intrusive /r/ were realised, moreover by nine different speakers and with no observable effect of both linguistic and non-linguistic factors, these tokens were excluded from subsequent analyses of the data. By contrast, linking /r/ (i.e. /r/ in syllable-final prevocalic (word boundary) position, e.g. *fo**r** a*) is the most commonly occurring type of syllable-final /r/ in SgE, and this is true for both speech styles - reading and conversation. This /r/-sandhi phenomenon is, again, not unexpected in SgE as it is known to be a feature present in non-rhotic accents of English (Wells, 1982). The fact that syllable-final /r/ is most often found in this position and that it can be realised as any of the /r/ variants that exist in SgE (although minimally for some variants) hints at the possibility of /r/ realisations in syllable-final prevocalic (word boundary) position to be underlyingly the same as those in word-internal intervocalic position for SgE. This phonological implication, however, needs to be further analysed for any conclusions to be made. Further evidence for syllable-final /r/ realisations in SgE can be seen in syllable-final consonant clusters (e.g. *ca**r**t*) and syllable-final non-prevocalic positions (e.g. *Bo**r**neo*, *ea**r***, *you**'re** just*) where a strong post-alveolar approximant (i.e. Score 4) is also the most common realisation in both reading and conversation. There are also, sometimes, weak post-alveolar approximant (i.e. Score 3) variants in these syllable-final positions. It appears probable for tap/trill (i.e. Score 5) and labiodental approximant (i.e. Scores 1 and 2) variants to occur in syllable-final non-prevocalic positions but further investigation revealed these to be once-off occurrences from different speakers and likely inconsequential. Due to the low frequency of each /r/ variant occurring in the various syllable-final positions, all syllable-final positions are merged and considered collectively when included alongside non-syllable-final realisations in the subsequent analyses.

Differences in the occurrence patterning of /r/ variants can be seen between the two speech styles (i.e. reading, conversation) (see Figures 4.3 and 4.4). Additionally, a comparison between Figure 4.5, which presents variants of /r/ according to the linguistic factors of phonological position and word class in combined speech, and Figure 4.6, which presents the same but in separate speech styles (i.e. reading, conversation), uncovers some levels of variation which might be overlooked if speech style was not considered. The factor of speech styles was therefore included in the analyses, facilitating a more accurate analysis of /r/ variation in SgE. As mentioned earlier, tokens of intrusive /r/ have been excluded and all other syllable-final positions have been merged as ‘syllable-final’.

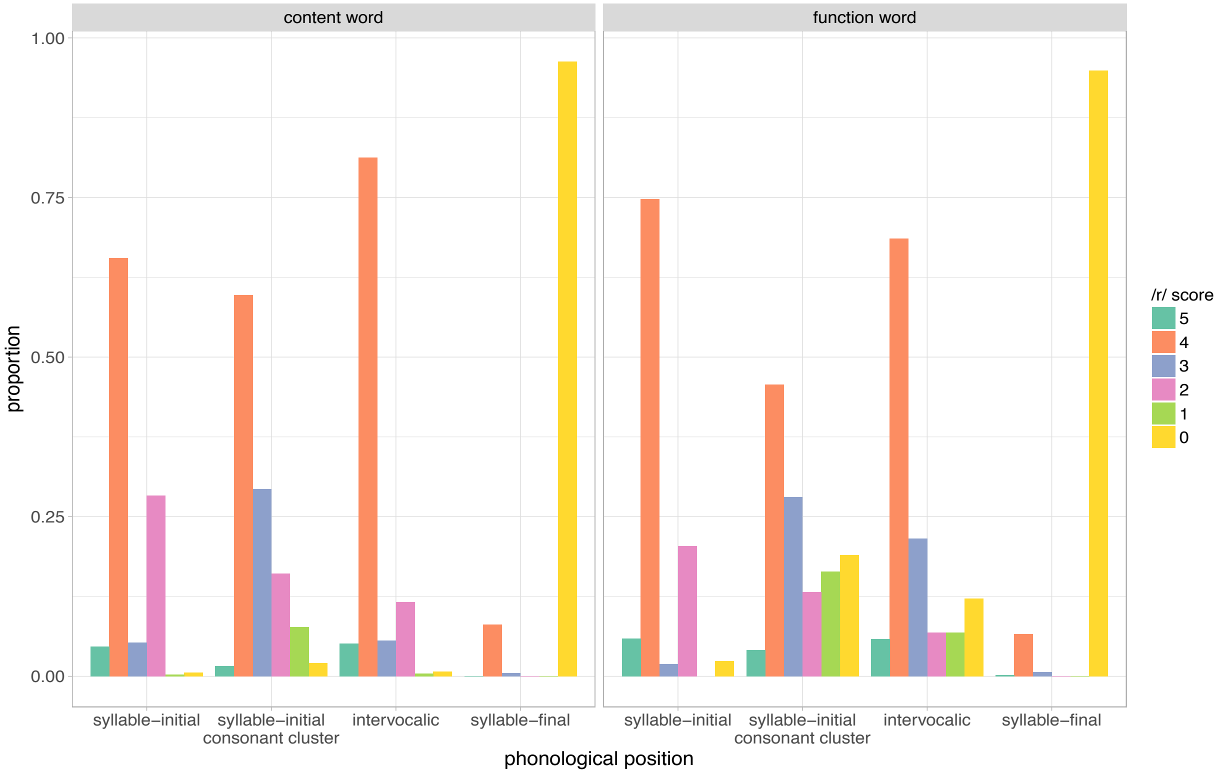

Figure 4.5: Variants of /r/ (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in combined speech (n = 41,748), according to phonological position and word class (presented in two columns: left – content word, right - function word), (proportions are calculated within phonological position and word class, e.g. all scores from syllable-final function word add up to proportion unit 1.0/100%).

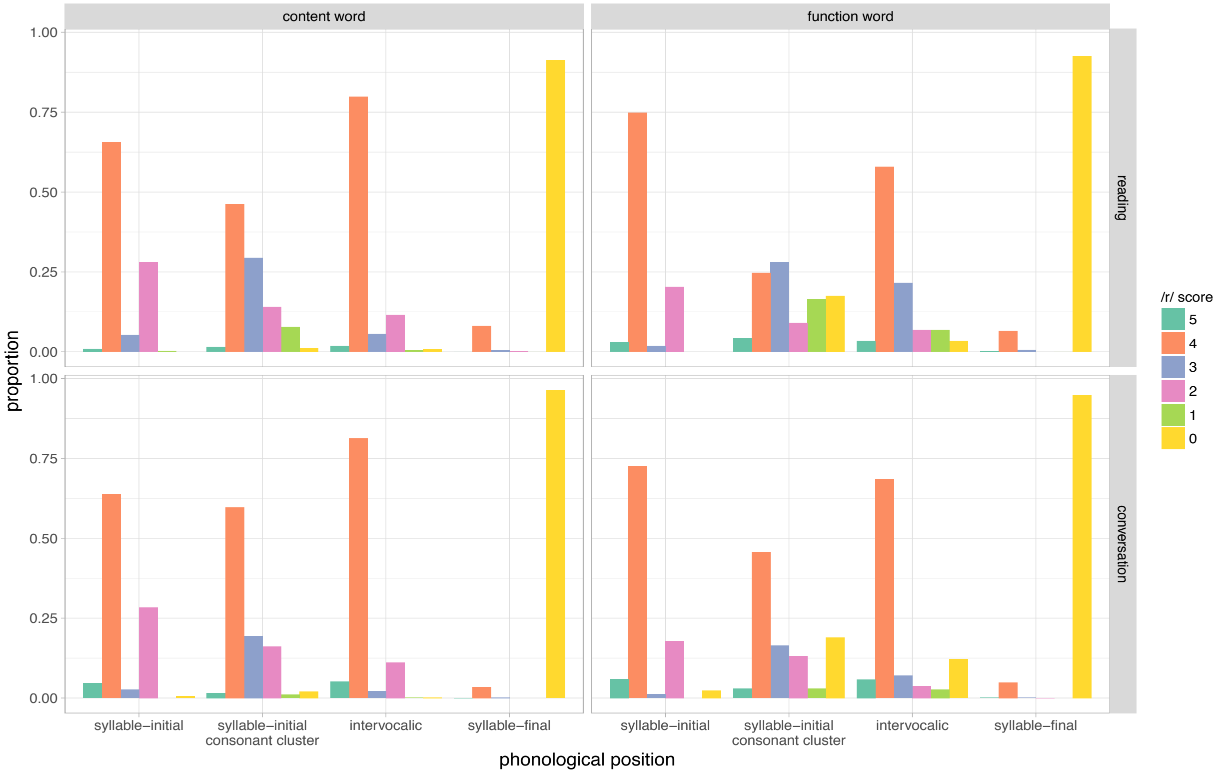

Figure 4.6: Variants of /r/ (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in reading (*n* = 23,674) and conversation (n = 18,074) (presented in two rows: top – reading, bottom – conversation), according to phonological position and word class (presented in two columns: left – content word, right - function word), (proportions are calculated within phonological position, word class, and speech style, e.g. all scores from syllable-final function word in reading add up to proportion unit 1.0/100%).

Figure 4.6 facilitates an overview of the ways in which various factors together affect /r/ variation in SgE. Differences between speech styles can be seen in the higher proportion of syllable-final realisations as strong post-alveolar approximants (i.e. Score 4) and labiodental approximants (i.e. Scores 1 and 2), for both content and function words, in reading than in conversation. For non-syllable-final realisations, in addition to effects of phonological position, /r/ variation is affected not only by speech style but also by word class and possibly a combination of speech style and word class. The effect of speech style on variation in non-syllable-final /r/ realisations can be seen, for example, in syllable-initial positions, where the proportions of null realisations (i.e. Score 0) and tap/trill (i.e. Score 5) occurrences are higher in conversation than in reading for both content and function words. Differences can also be seen between word class, where the proportions of strong post-alveolar approximant (i.e. Score 4) realisations in each non-syllable-final position is higher in content words than in function words for both reading and conversation. More interestingly, while the proportions of /r/ variants within the various phonological positions of content words pattern relatively similarly between the speech styles, there is variation between reading and conversation in the proportions of /r/ variants within syllable-initial consonant clusters and intervocalic positions of function words. There are observably higher proportions of strong post-alveolar approximant (i.e. Score 4) and strong labiodental approximant (i.e. Score 2) realisations in syllable-initial consonant clusters of conversational function words, and, conversely, higher proportions of weak post-alveolar approximant (i.e. Score 3) and weak labiodental approximant (i.e. Score 1) realisations in those of read function words. The extent of these differences is seen particularly when comparing, across speech styles, between the proportions of strong and weak variants of post-alveolar approximants (i.e. Scores 3 and 4), and also between those of strong and weak variants of labiodental approximants (i.e. Scores 1 and 2). Some of these initial observations fulfill our expectations of speech style effects while others do not. What is revealed here, however, is the possibility of the effects of other confounding variables. To facilitate more substantial discussion, statistical analyses, which enable the combined consideration of effects of linguistic factors and speech style on /r/ realisation in SgE, were therefore carried out and are reported in Sections 4.4 and 4.5.

Given the multi-faceted nature of SgE, other than the effects of linguistic factors and speech style, those of other non-linguistic factors (i.e. age, speaker sex, ethnicity) also need to be considered. Due to the disproportionately large number of null realisations in syllable-final positions as mentioned earlier, studying non-syllable-final and syllable-final /r/ separately was vital for reliable conclusions. Low frequency of syllable-final /r/ realisations in general also made it computationally necessary for syllable-final /r/ and non-syllable-final /r/ to be analysed separately in the statistical tests. The remainder of this section thus describes non-linguistic effects first on non-syllable-final /r/ realisations, then on syllable-final /r/ realisations in SgE.

Figure 4.7 plots the effect of age on the frequency of occurrence of /r/ variants in non-syllable-final positions. It can be seen, across all subgroups, that following the most dominant /r/ variant, the post-alveolar approximant (i.e. Scores 3 and 4), the next most common /r/ realisation in SgE is the labiodental approximant (i.e. Scores 1 and 2). For speakers who do not use many labiodental approximants (i.e. Scores 1 and 2), the next most common /r/ realisation is the tap/trill (i.e. Score 5). Within speakers, the frequency of labiodental approximant (i.e. Scores 1 and 2) occurrence and that of taps/trills (i.e. Score 5) also appears to be in inverse proportion. This relationship of inverse proportion also holds true between the frequency occurrences of labiodental (i.e. Scores 1 and 2) and post-alveolar (i.e. Scores 3 and 4) approximants. In general, it is observable that ethnically Chinese females and males from the middle age group (i.e. late 20s – late 30s) tend to have more labiodental approximant (i.e. Scores 1 and 2) realisations whereas this effect lessens for their counterparts in the older and younger age groups. A similar observation can be made of ethnically Indian females and since ethnically Indian males in the middle age group behave in the same way as their female counterparts, it seems probable for the same effect to apply to them as well. The claim for ethnically Indian males, however, can only be inferred as there are no younger and older age group data in the sample for this group. For ethnically Malay females, and ethnically Eurasian females and males, it is speakers from the younger age group who are seen to have more labiodental approximant (i.e. Scores 1 and 2) realisations than those from the middle and older age groups. There is no observable age effect on the use of labiodental approximants (i.e. Scores 1 and 2) for ethnically Malay males and the same can be said of taps/trills (i.e. Score 5) for this group of SgE speakers. The tap/trill (i.e. Score 5) appears to be a variant that is used more by speakers of the older age group for ethnically Chinese and Indian males. However, as for ethnically Malay males, the effect of age on tap/trill (i.e. Score 5) occurrences does not seem to be applicable for all female speakers and ethnically Eurasian males. It should be noted that these observations are based on an analysis of the graphical illustration of data collected, as seen in Figure 4.7, and as the sample sizes for some ethnic groups (e.g. Indians and Eurasians) are generally smaller, especially the younger and older age groups for some subgroups as mentioned (e.g. Indian males), it was not computationally possible to obtain statistical evidence for age effect. Caution is therefore particularly needed when interpreting age effects for these groups. Nevertheless, these are preliminary findings which contribute a valuable outlook of not only variation but also change in /r/ realisation in SgE.

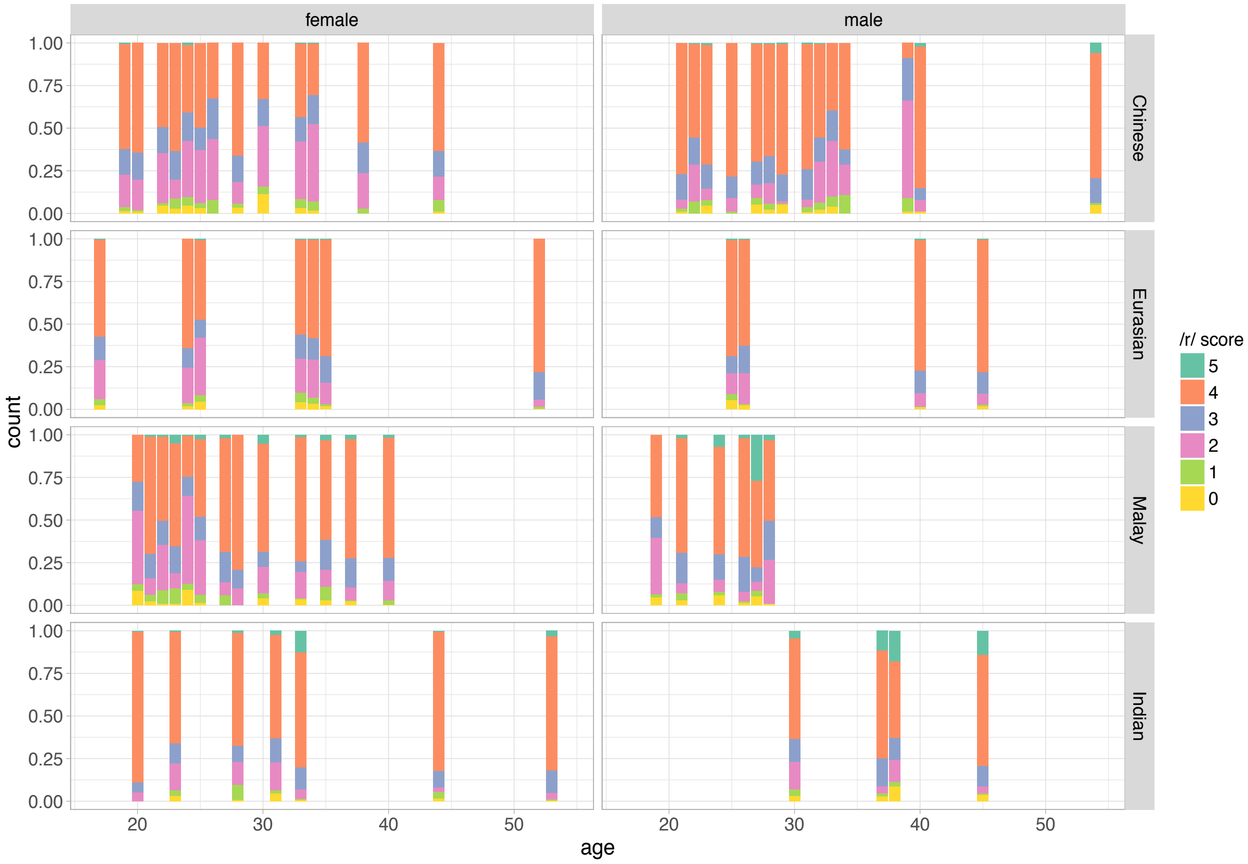

Figure 4.7: Variants of non-syllable-final /r/ (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in combined speech data, according to age, ethnicity (presented in four rows: top to bottom – Chinese, Eurasian, Malay, Indian) and speaker sex (presented in two columns: left – female, right - male), (n = 17,886). Note: Caution is needed in interpreting age effects for ethnic/speaker sex groups with small sample sizes.

The observations of /r/ variation as described in the previous paragraph resultantly suggest that in addition to the effects of age, ethnicity effects might also be present with the ethnically Chinese group of speakers leading a process of /r/ 'weakening' in SgE. Plotting the data according to ethnicity as done in Figure 4.8 further illustrates this hypothesis. Here, it is clear that the ethnically Chinese SgE speakers have the highest proportion of weak and strong labiodental approximants (i.e. Scores 1 and 2), and weak post-alveolar approximants (i.e. Score 3), and the lowest proportion of strong post-alveolar approximants (i.e. Score 4) as compared to the other ethnic groups. They are followed by the ethnically Malay and Eurasian SgE speakers who, other than having differences in proportions of strong post-alveolar approximants (i.e. Score 4) and taps/trills (i.e. Score 5), pattern rather similarly in the frequencies of occurrence of their other /r/ variants. Ethnically Indian SgE speakers have the highest proportions of both strong post-alveolar approximants (i.e. Score 4) and taps/trills (i.e. Score 5) and, conversely, the lowest proportions of weak and strong labiodental approximants (i.e. Scores 1 and 2), and weak post-alveolar approximants (i.e. Score 3).

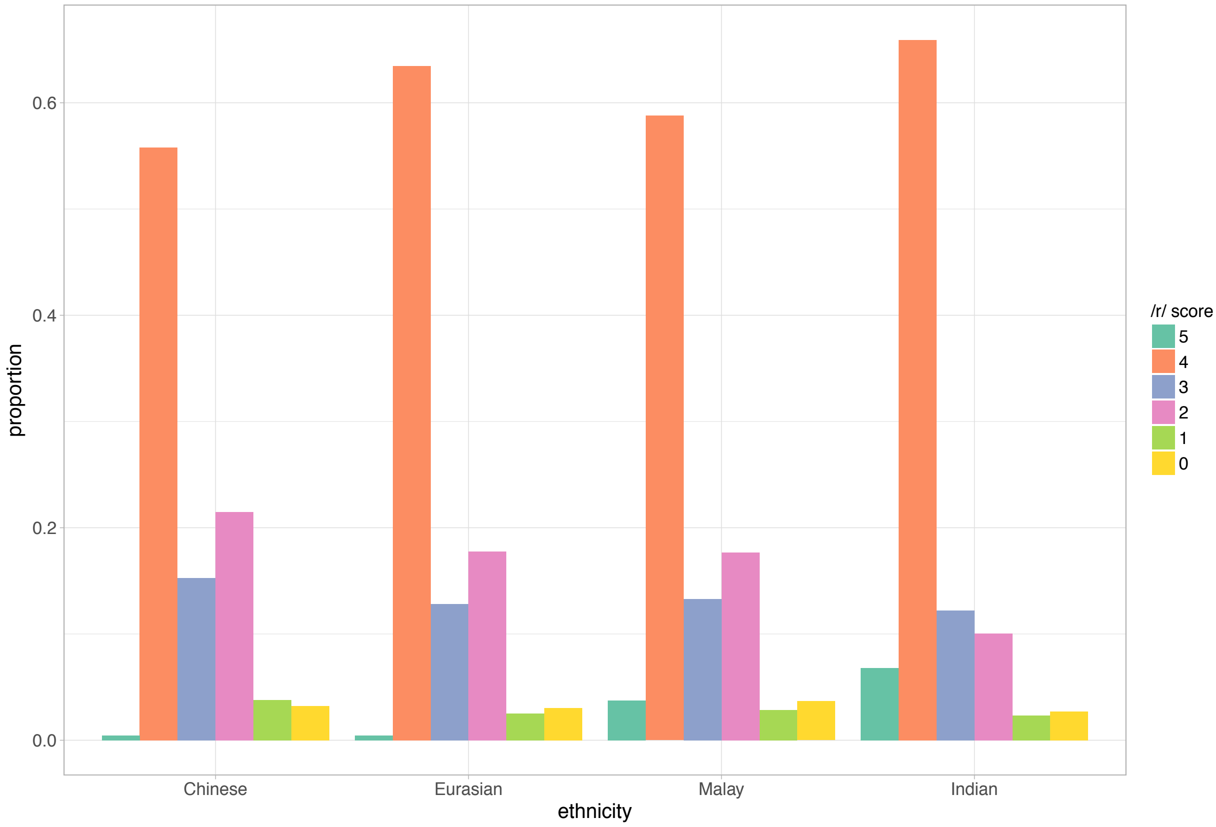

Figure 4.8: Variants of non-syllable-final /r/ (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in combined speech, according to ethnicity, (n = 17,886).

Finer details can be seen when effects of ethnicity are combined with those of speech style, as seen in Figure 4.9. For example, ethnically Chinese SgE speakers have a higher proportion of strong labiodental approximant (i.e. Score 2) realisations in conversation than in reading while the reverse pattern is true for ethnically Eurasian SgE speakers. The degree of difference, however, was smaller for ethnically Eurasian SgE speakers.

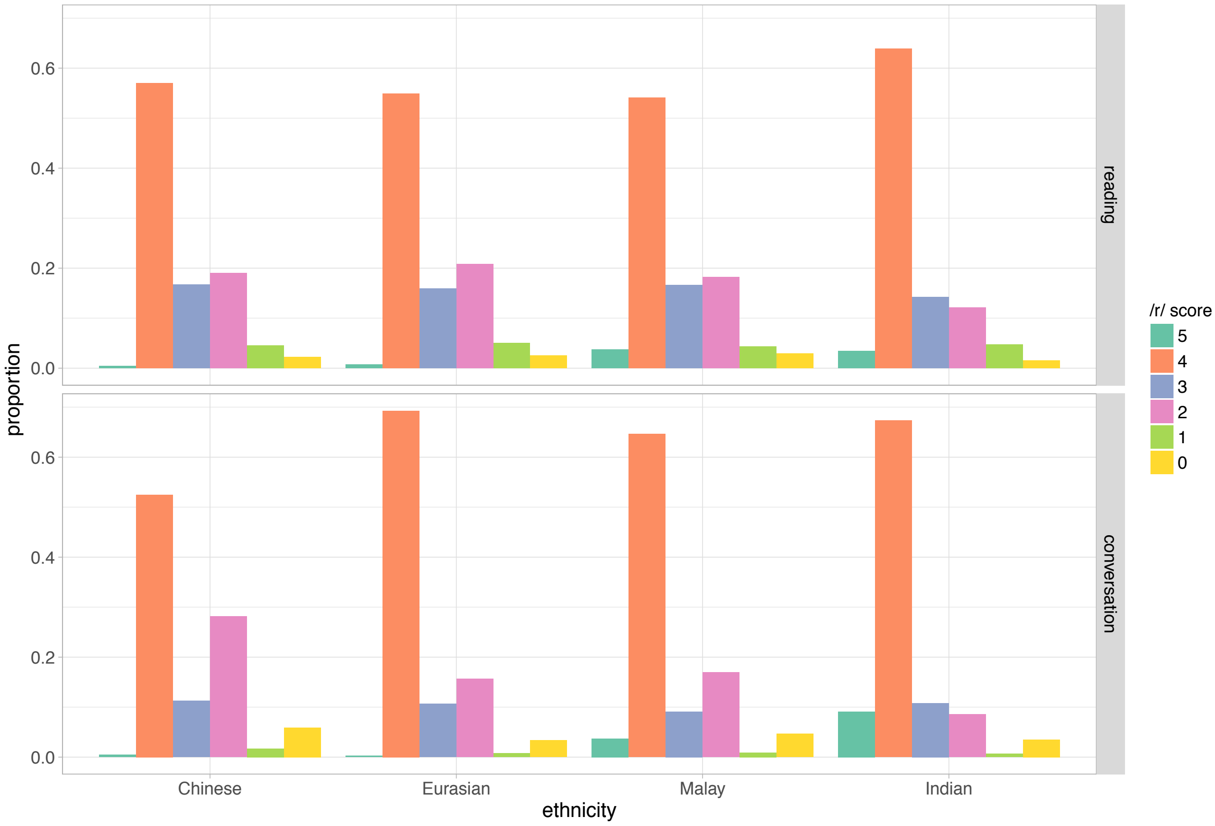

Figure 4.9: Variants of non-syllable-final /r/ (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in reading (n = 10,001) and conversation (n = 7885) (presented in two rows: top – reading, bottom – conversation), according to ethnicity.

Alongside age and ethnicity, speaker sex is another non-linguistic factor that has been reported to effect variation (e.g. Kwek, 2012). Effects of speaker sex can be clearly seen in Figure 4.10. While the proportions of null realisations (i.e. Score 0), weak labiodental approximants (i.e. Score 1), and weak post-alveolar approximants (i.e. Score 3) are relatively similar for both males and females, differences can be observed in the proportions of strong labiodental approximants (i.e. Score 2), strong post-alveolar approximants (i.e. Score 4), and taps/trills (i.e. Score 5) between the two groups. Females use more strong labiodental approximants (i.e. Score 2) while males use more strong post-alveolar approximants (i.e. Score 4) and taps/trills (i.e. Score 5). This also reiterates the earlier observation of these variants being inversely proportional. Speaker sex effects do not appear to be affected by speech styles as illustrated in Figure 4.11 where the difference in proportions of each /r/ variant between males and females is the same across both reading and conversation.

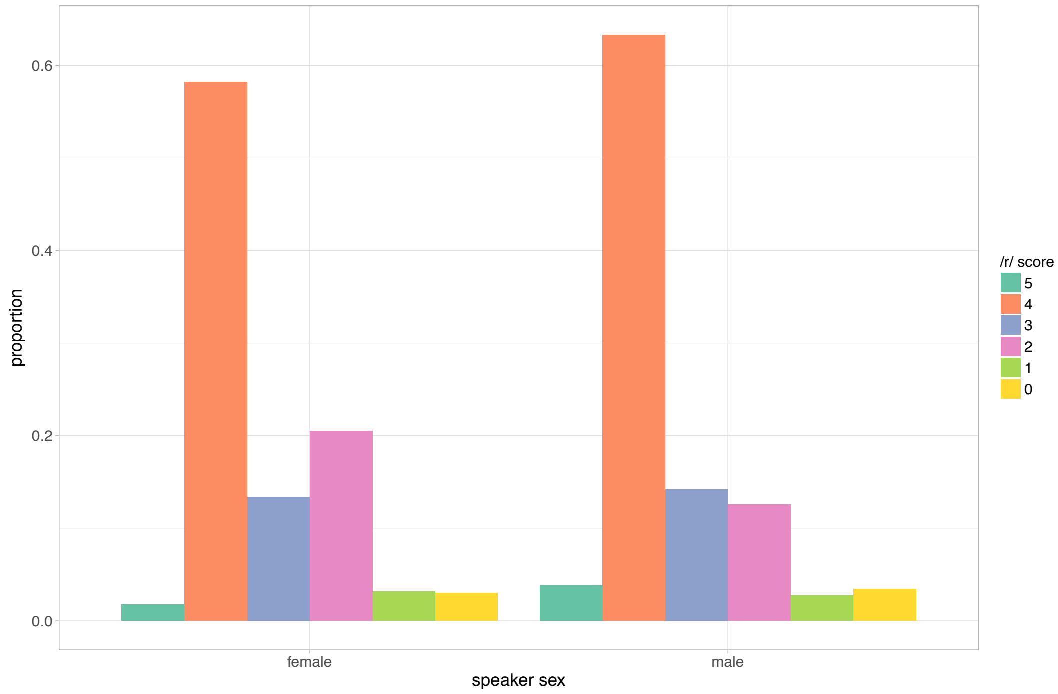

Figure 4.10: Variants of non-syllable-final /r/ (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in combined speech, according to speaker sex, (*n* = 17,886).

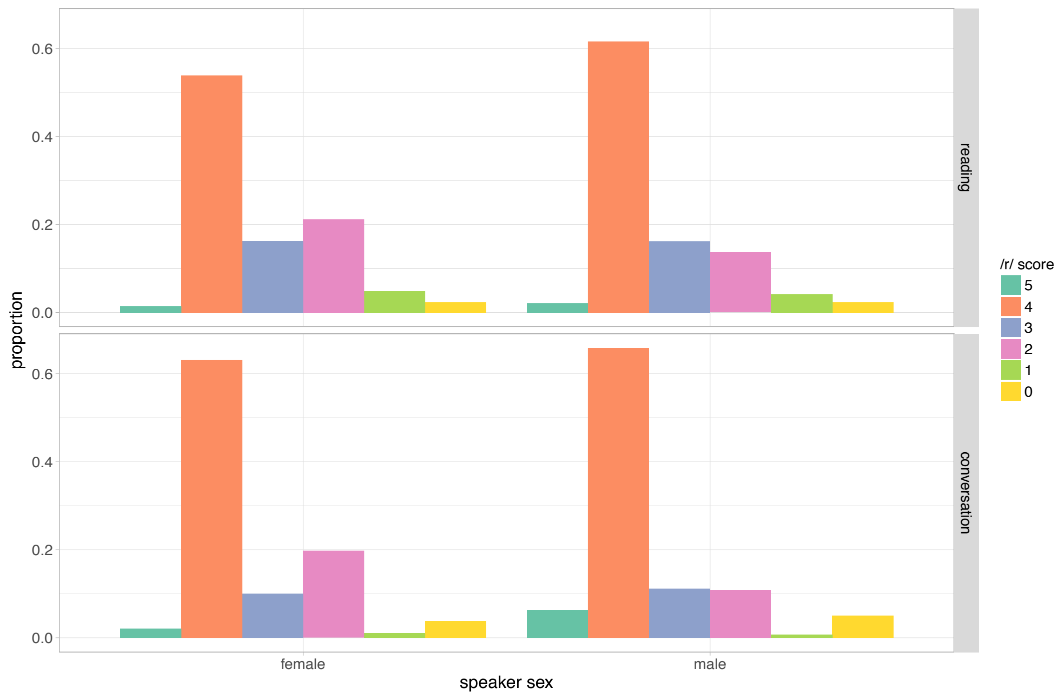

Figure 4.11: Variants of non-syllable-final /r/ (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in reading (*n* = 10,001) and conversation (n = 7885) (presented in two rows: top – reading, bottom – conversation), according to speaker sex.

As done for non-syllable-final /r/, the effects of age, speech style, speaker sex, and ethnicity on syllable-final /r/ were also considered. From Figure 4.12, some form of age effect on syllable-final /r/ realisation can be seen. In general, SgE speakers in their mid-30s and younger tend to have more syllable-final /r/ realisations. This is true across ethnic and speaker sex groups.

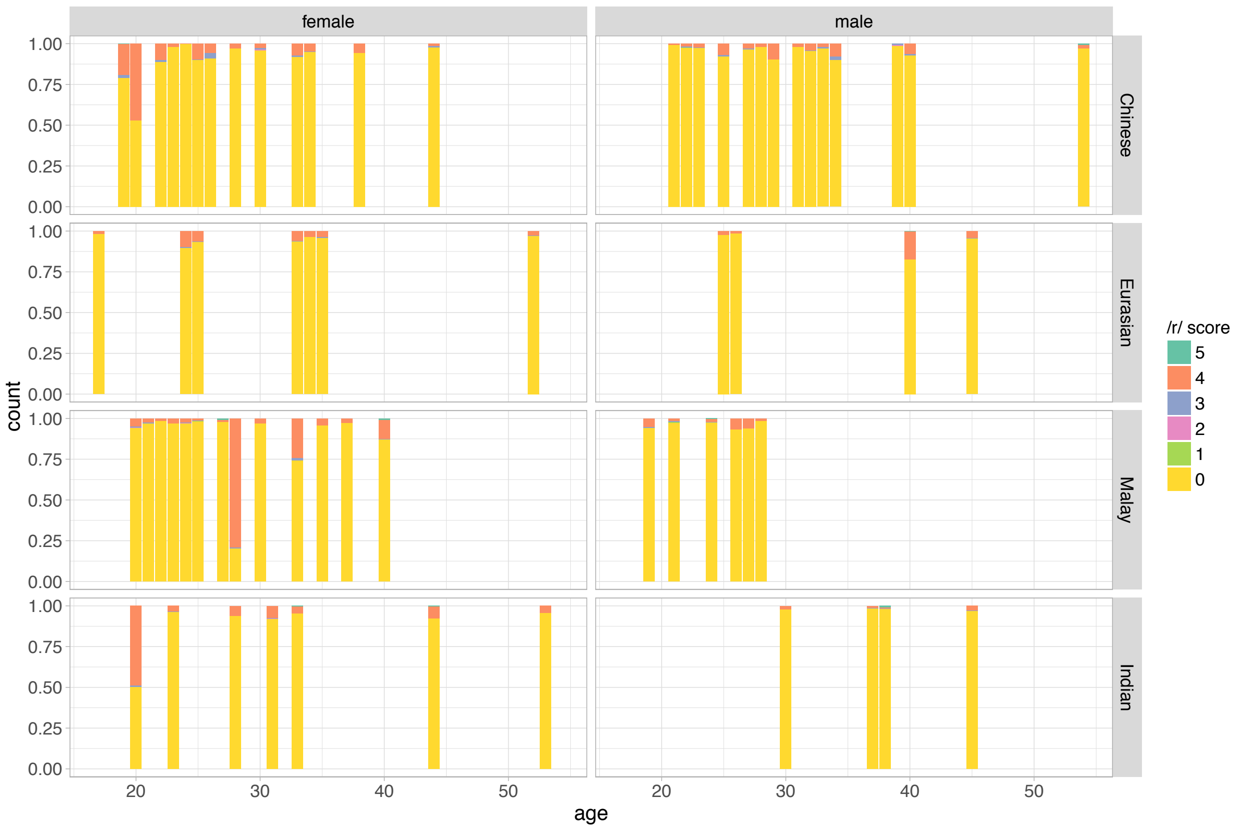

Figure 4.12: Variants of syllable-final /r/ (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in combined speech data, according to age, ethnicity (presented in four rows: top to bottom – Chinese, Eurasian, Malay, Indian) and speaker sex (presented in two columns: left – female, right - male), (n = 23,862).

It is also evident, as illustrated in Figures 4.13 and 4.14, that, in addition to a higher proportion of syllable-final /r/ realisation occurring in reading than in conversation, female SgE speakers are more likely to have syllable-final /r/ realisations than their male counterparts. Not much can be said of ethnicity effects at this point except for the fact that ethnically Malay and Indian SgE speakers appear to have higher proportions of syllable-final /r/ realisations.

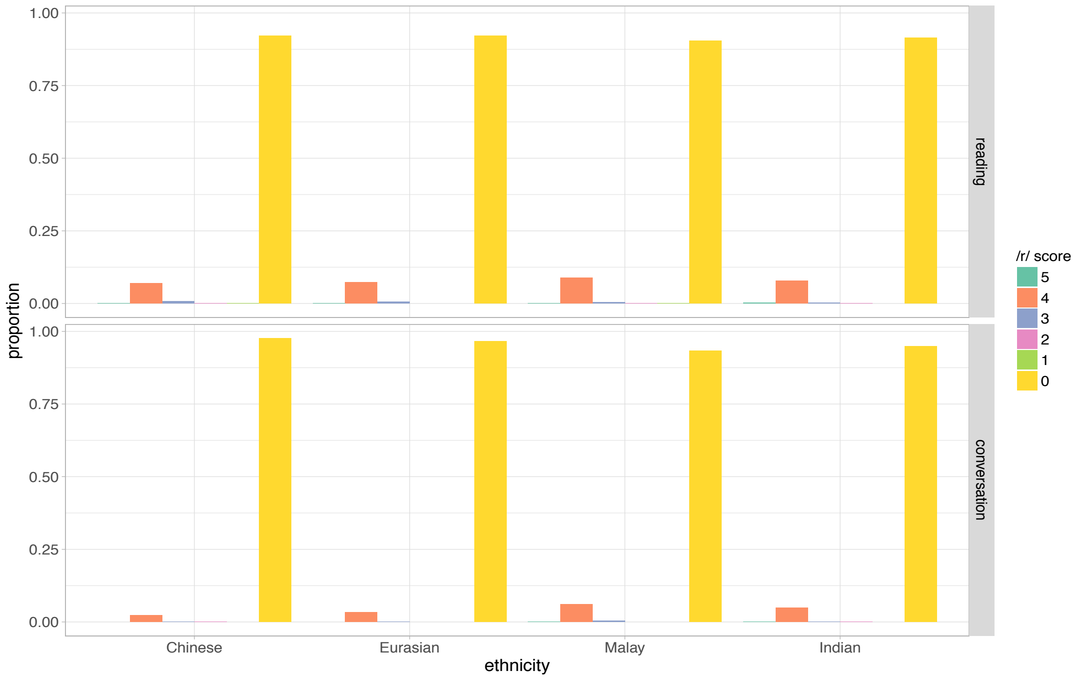

Figure 4.13: Variants of syllable-final /r/ (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in reading (*n* = 13,673) and conversation (*n* = 10,189) (presented in two rows: top – reading, bottom – conversation), according to ethnicity.

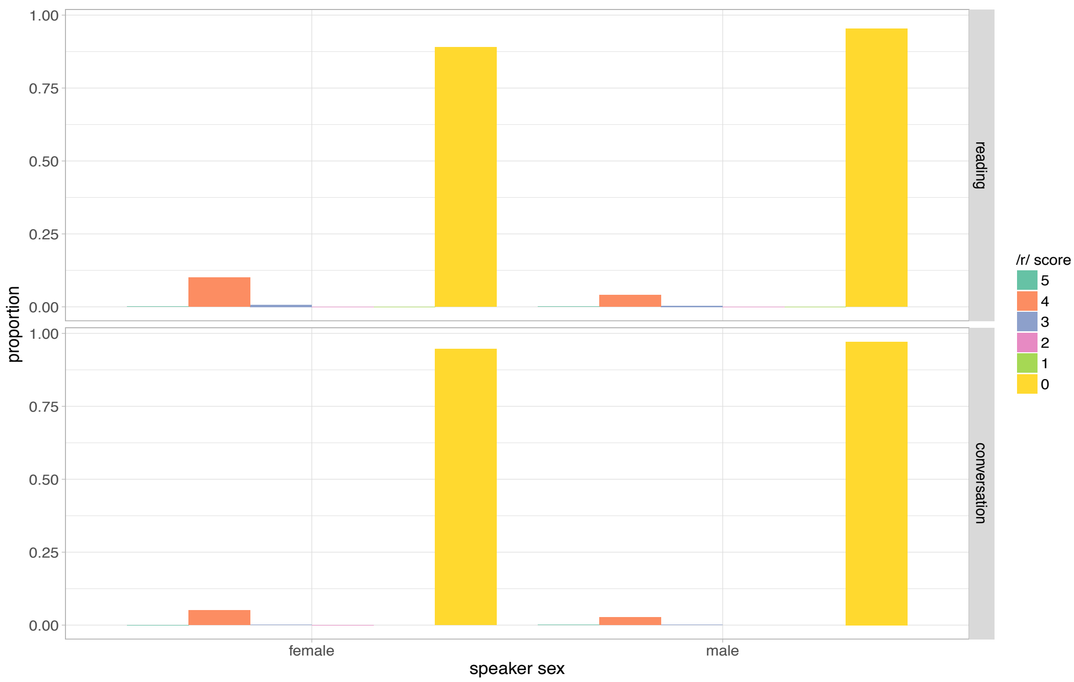

Figure 4.14: Variants of syllable-final /r/ (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in reading (*n* = 13,673) and conversation (*n* = 10,189) (presented in two rows: top – reading, bottom – conversation), according to speaker sex.

This overview reveals various interesting aspects of /r/ variation in SgE. They are, however, impressionistic observations which can be further enhanced by statistical analyses. Nonetheless, what is highlighted thus far is the need for a multidimensional approach in the study of /r/ variation in a multifaceted variety like SgE, taking into account not only the effects of various individual factors but also the effects of combinations of factors (i.e. interactions between factors). With this in mind, the following sections build on these initial observations, contributing a wider scope of analysis as well as more extensive statistical evidence wherever possible.

4.3 Motivations for choice of inferential statistics models

Presented in Section 4.2 are observations based on raw percentages and thus in the attempt to study more systematically the extent to which interacting linguistic and non-linguistic factors condition /r/ realisation in SgE, inferential statistics were done. The subject of study, however, is inherently multifaceted and resulted in a complex model which is multinomial, multivariate, and multilevel. The outcome variable is multinomial (i.e. six categories for /r/ score) due to the auditorily and acoustically fine-grained distinctions made in the attempt to reflect the phonetic complexity of /r/. The model is multivariate because of the many predictor variables, both linguistic and non-linguistic, involved in the eventual selection of /r/ variant by SgE speakers. And, each predictor variable is multilevel as they have the potential to take on different categories (e.g. ethnicity has four levels – Chinese, Eurasian, Malay, Indian). These complexities therefore caused some challenges in the processes of model selection and model building. There was a fundamental dilemma in model selection whereby models suitable for sociophonetic studies of this sort (Hay, 2011) had different advantages and limitations. A linear mixed-effects (LME) model could include random effects which account for individual speaker variation but it simplifies the outcome variable (i.e. the scale of Score 5 – 0) in a theoretically undesirable way, while a multinomial logistic regression (MLR) model cannot account for individual speaker variation but is able to give more comprehensible insight on the multinomial outcome. Also, theoretical considerations in model building were limited by the complexity of the data structure (i.e. being both multivariate and multilevel), which quickly becomes computationally intensive; it was not always computationally possible to include all forms of interactions. Eventually, both the LME and

MLR models were fitted to the data, and factors and, especially, their interactions were only considered if they resulted in converged models. These were done with the aim of ensuring a more accountable statistical analysis, enabling a more valid and reliable approach to understanding the multidimensional nature of the data. The challenges and considerations, as mentioned, are further detailed in the following sections.

4.3.1 Considering random effects

Fixed effects models have been traditionally implemented in the analysis of natural language data through software such as GoldVarb (Sankoff, Tagliamonte, & Smith, 2005; Tagliamonte, 2006 in Johnson, 2009). However, they run the danger of underestimating the significance of between-speaker predictors (Winter, 2011). In doing so, individual speaker variation tends to be ignored and the significance of statistical tests may be inflated (e.g. Sigley, 2003:228 in Johnson, 2014). Despite this limitation, fixed effects models are still being used (e.g. Bowie, 2012 in Johnson, 2014). In the past decade, there has been a rise in the popularity of utilising mixed-effects regression models to analyse sociolinguistic data instead (Johnson, 2014). The benefit of a mixed effects model is its ability to account for individual variation through the delineating and inclusion of random effects (e.g. speaker) in the generation of estimations for the effects of predictors (e.g. speaker sex) (Johnson, 2014). Considering the nature of this study's data, using an LME model was therefore necessary in testing the effects of linguistic and non-linguistic factors on /r/ realisations in SgE.

An LME model was fitted to the data using the *lmer* function in the lme4 (Bates et al., 2017) and lmerTest (Kuznetsova, Brockhoff, & Christensen, 2016) packages in R (R Core Team, 2016). The outcome variable was '/r/ score', consisting of six categories of /r/ variants, as stated in Section 4.2. The predictor variables/fixed effects included categorical ones – phonological position (7 levels), word class (3 levels), following context (13 levels), speech style (2 levels), speaker sex (2 levels), and ethnicity (4 levels), and a continuous one – age (17 – 54); see Section 3.2 for details. In addition to these fixed effects, interactions between them were also included in the model. It should be noted here that, because of the fundamental conflict of model complexity and model convergence as outlined earlier, the decision of not pursuing overly complicated interactions and creating an impractically large model was made.

Therefore, only two-way interactions (e.g. age:ethnicity) were included and interactions with factors which had too many levels (i.e. interactions with 'following context') were left out. To address the inherent assumptions of independence (Winter, 2013), random intercepts for both speaker and word were also added. Including these random intercepts accounted for the possibility of baseline-differences in realisation of /r/ (i.e. /r/ score) – by-speaker and by-item variability (Winter, 2013). In all tests involving an LME analysis, the model used was fitted using restricted maximum likelihood (REML) and *p*-values were derived using Satterthwaite approximations, a method which, alongside Kenward-Roger approximations, has been found to be preferable as it produces 'the most consistent Type 1 error rates, being neither anti-conservative nor overly sensitive to sample size' (Luke, 2017:1500).

An LME model was first used to test the role of random intercepts for both speaker and word through an analysis of their effects on the resultant parameters which are presented on the x-axis of Figure 4.15. This was done by comparing two models, one with random effects and one without. Illustrated in Figure 4.15 are the differences in coefficients and confidence intervals (represented by the length of bars) for the predictions of parameters between an LME random intercept model which includes random intercepts for both speaker and word (bottom bars; red) and an LM model which does not include random effects at all (top bars; blue). Results of the LM model were derived from fitting a linear model to the data using the *lm* function in the stats package in R (R Core Team, 2016). Both models included the same parameters with only a difference in random effects structure. It is clear that when random intercepts for speaker and word are included in the model (i.e. LME random-intercept model), the confidence intervals generally widen, indicating less certainty (i.e. red bars are longer). At the same time, and arguably more importantly, the direction of effect (i.e. positive/negative coefficient) for a number of parameters changes after accounting for individual variation. For example, the effect of being ethnically Indian on /r/ realisation changes from one that is definitely a negative coefficient to being almost as likely positive as it is negative once random intercepts for speaker and word are included in the model (see section in Figure 4.15 marked by a purple arrow). A definite positive coefficient for interactions between syllable-initial position and function word class, and Malay ethnicity and male speaker sex also becomes as likely negative when the model accounts for speaker and word random intercepts (see sections in Figure 4.15 marked by orange arrows). These therefore imply that significance of effects in a fixed effects model, which does not include random effects, needs to be interpreted with caution as patterns of certain effects might be due to the behaviours of individual speakers and not generalisable to the entire group. Additionally, when significance testing between models was carried out, using the *anova* function in the lmerTest package (Kuznetsova et al., 2016) in R (R Core Team, 2016), where both models were fitted with maximum likelihood (ML) and Satterthwaite approximation was implemented, a significant difference (p < 2.2e-16) between the two models was found. These thus give reasons for including random intercepts for both speaker and word in the LME model.

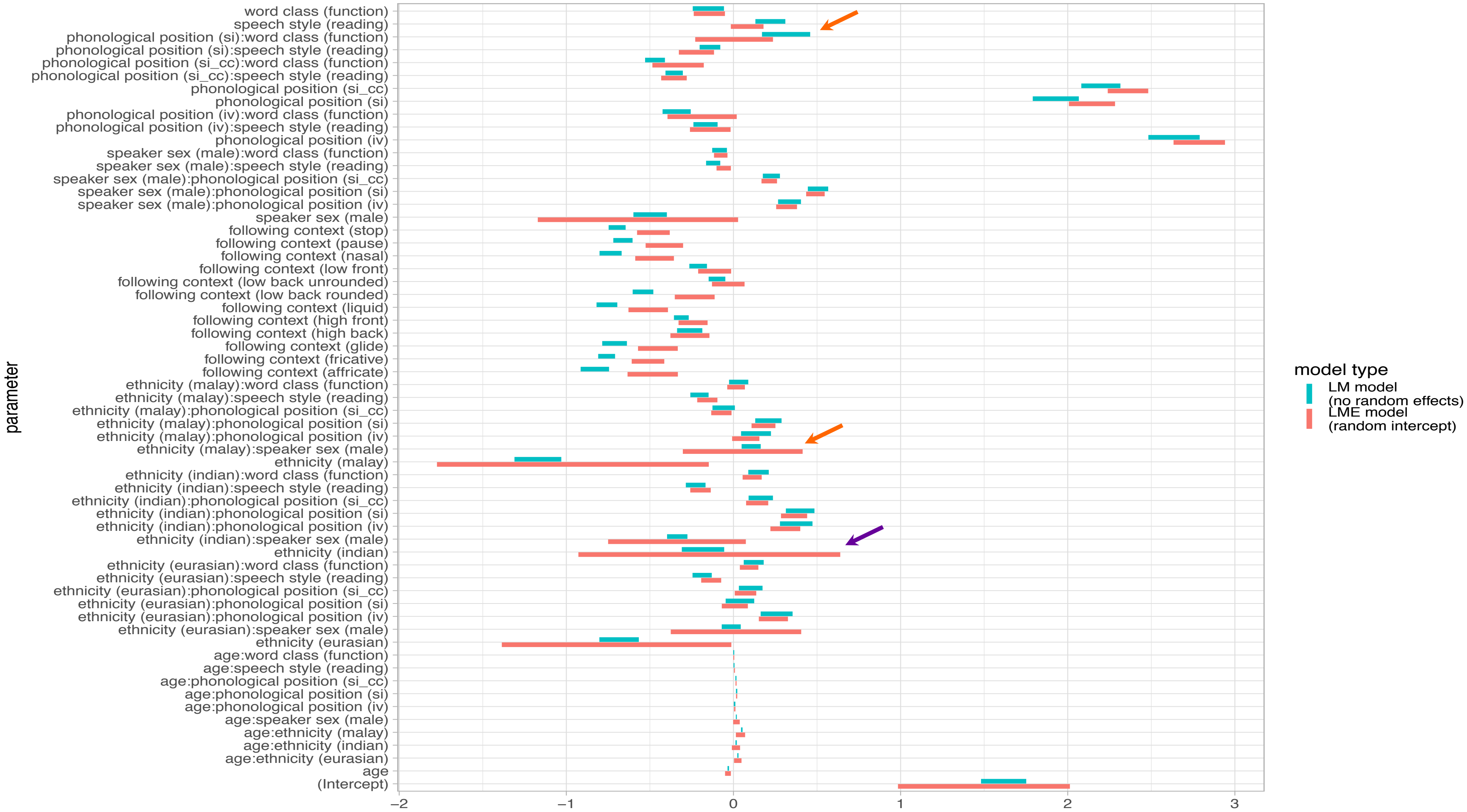

Figure 4.15: Comparison of an LM model – with no random effects (top bars; blue) and an LME random intercept model – with random intercepts for speaker and word (bottom bars; red). Phonological position codes: 'si' – syllable-initial, 'si_cc' – syllable-initial consonant cluster, 'iv' – intervocalic. Arrows are explained in preceding text.

It has been reported that it is also crucial to account for, besides speakers' differing baselines, the fact that the effect of predictors (i.e. fixed effects) could be different for different speakers (Barr, Levy, Scheepers, & Tily, 2013; Clark & Watson, 2016). Including not only random intercepts for speaker and word but also random by-speaker slopes for linguistic factors (i.e. phonological position, word class, following context) allows for both differing baseline /r/ scores and differing responses to the linguistic factors in question (Barr et al., 2013; Winter, 2013). Random by-speaker slopes for phonological position, word class, and following context were thus also initially added to the LME model. However, the model did not converge when all three by-speaker random slopes were included. As this suggested that meaningful information was not necessarily available to support random slope for each of the three linguistic factors, each of them was excluded in turn until convergence was reached. Only random by-speaker slope for phonological position was retained.

To avoid erroneously assuming the necessity of accounting for the fact that speakers might have differing responses to the effect of phonological position and resultantly running the risk of forming an unnecessarily maximal random effect structure which might pose practical computational problems, the LME random slope model (i.e. with by-speaker random slope for phonological position) was compared with the LME random intercept model (i.e. same model but with random intercepts for speaker and word) by applying the Satterthwaite approximation (ML-fitted) using the *anova* function from the lmerTest package (Kuznetsova et al., 2016) in R (R Core Team, 2016) as done before. The results showed significant differences between the two (p < 2.2e-16), supporting the inclusion of by-speaker random slope for phonological position in the LME model. The comparison of coefficients and confidence intervals of the parameters tested in both models is plotted in Figure 4.16. Top bars (red) represent the LME random intercept model, bottom bars (grey) represent the LME random slope model, and the length of bars represents the confidence interval. It appears that when by-speaker random slope for phonological position is included in the model, the outstanding differences lie in effects on phonological positions and more specifically in some of the interactions between ethnicity (Malay, Indian, Eurasian) and phonological positions (see sections in Figure 4.16 marked by black arrows). In these interactions, not only are confidence intervals wider (i.e. grey bars are longer) but, for some, the direction of effect of the parameter on /r/ realisation, in the random slope model, is also possibly either positive or negative when it is only one or the other in the random intercept model. The LME models used in the analyses of this study therefore always included a random effects structure that comprised intercepts for word and speaker, as well as by-speaker random slope for the effect of phonological position.

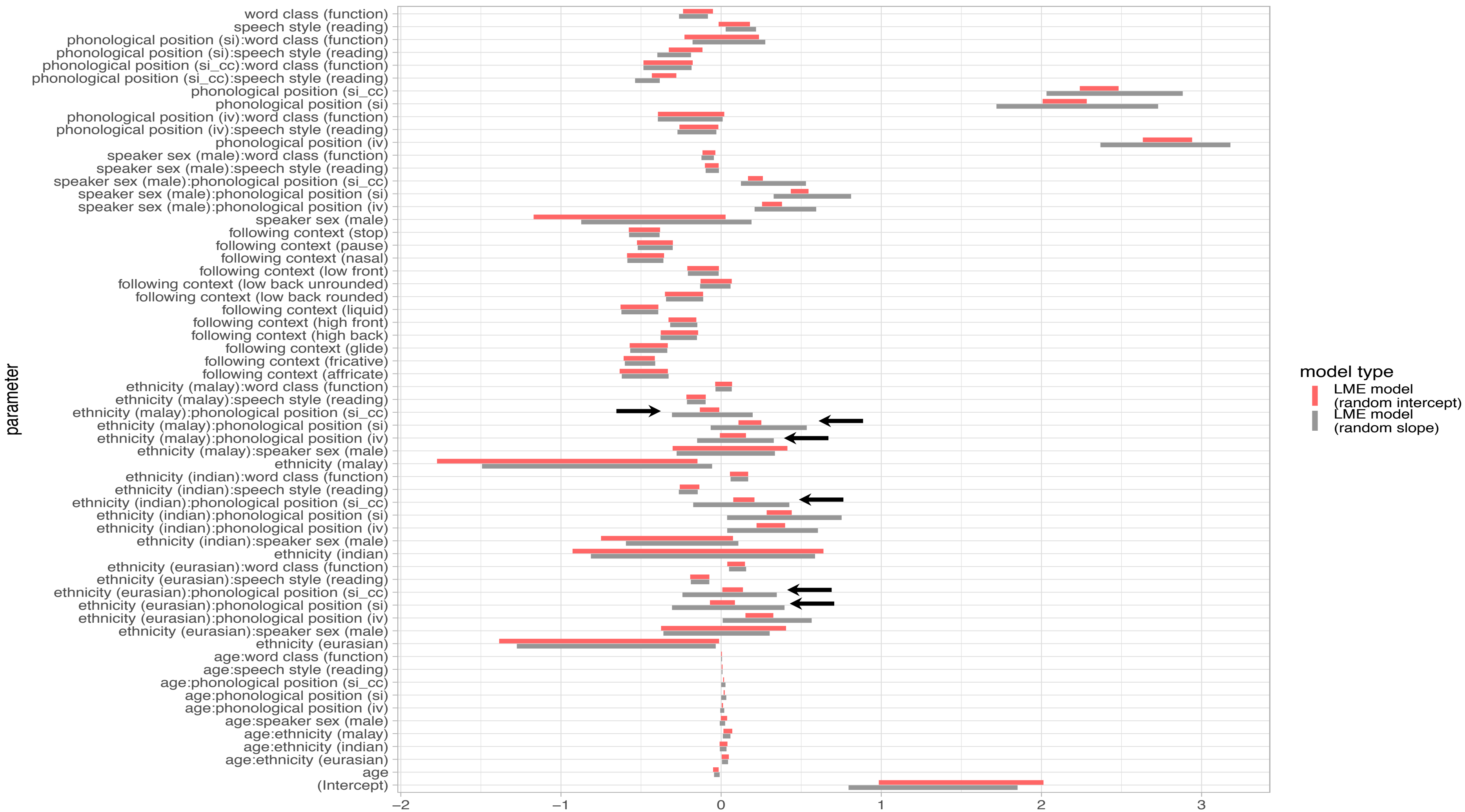

Figure 4.16: Comparison of two LME models; a random intercept model – with random intercepts for speaker and word (top bars; red) and a random slope model – with by-speaker random slope for phonological position and random intercepts for speaker and word (bottom bars; grey). Phonological position codes: 'si' – syllable-initial, 'si_cc' – syllable-initial consonant cluster, 'iv' – intervocalic. Arrows are explained in preceding text.

4.3.2 Considering the nature of predictor and outcome variables

It is thus seen that the LME model not only helps to identify the parameters which have significant effects on /r/ realisation and are worth focusing on, but also gives a general overview of random effects as well as individual speaker variation. However, although it is beneficial in allowing for the accounting of random effects, as evidenced in Section 4.3.1, it tends to mask the finer picture of specific types of /r/ variants present in SgE. This is due to the fact that it treats the multinomial outcome variable (i.e. /r/ score) as a continuous variable and therefore calculates an estimate which is challenging to interpret. For example, a tap/trill (i.e. Score 5) is not 2.5 times of a strong labiodental approximant (i.e. Score 2) as using the LME model would assume. In view of this limitation, in addition to an LME model, an MLR (i.e. multinomial linear regression) model was also fitted to the data using the *multinom* function in the nnet package (Ripley & Venables, 2016) in R (R Core Team, 2016). With the MLR model, it is possible to obtain the predicted probability for each level of the outcome variable (i.e. each /r/ score/variant) for every parameter. It not only rightfully treats the outcome variable as categorical but also allows for analyses of multinomial, instead of just binomial, variables. However, because it is computationally intensive, the random structure estimate was not implemented in the MLR model. Therefore, since the MLR model does not include random effects of speaker and word in its analysis, both models (i.e. LME and MLR) had to be jointly used in the analyses of the data. To ensure consistency and valid analyses, the same fixed effects and interactions were included in the fitting of both models.

What follows is a presentation of results from performing both an LME analysis and an MLR analysis on a full model. This serves to illustrate the benefits and limitations of results generated from both statistical models and also how the analyses and presentation of statistical results were eventually done. Adopting the argument of forming maximally-fitted models and more specifically that of retaining factors which make sense to the study but not necessarily found to be significant in the model(s) (Gelman & Hill, 2007:69), and also taking into consideration random effects and convergence as discussed, the full model includes all /r/ tokens (except intrusive /r/ ones) from both read and conversational speech, and has parameters as shown in Table 4.6.

Table 4.6: Parameters of the full model; combined read and conversational speech.

Fixed effects (7)	**Interactions (14)**	
Age	Age : Ethnicity	Ethnicity : Phonological position
Ethnicity	Age : Speaker sex	Ethnicity : Word class
Speaker sex	Age : Speech style	Speaker sex : Speech style
Speech style	Age : Phonological position	Speaker sex : Phonological position
Phonological position	Age : Word class	Speaker sex : Word class
Word class	Ethnicity : Speaker sex	Speech style : Phonological position
Following context	Ethnicity : Speech style	Phonological position : Word class

An LME analysis was first carried out. For this, the full LME model also had a random effects structure of by-speaker random slope for phonological position, and random intercepts for speaker and word. It was fitted by restricted maximum likelihood (REML) and *p*-values were derived using Satterthwaite approximation to degrees of freedom. The first level of LME analysis included a preliminary analysis of variance, using the *anova* function in the lmerTest package (Kuznetsova et al., 2016) in R (R Core Team, 2016). This showed linguistic factors (i.e. phonological position, word class, following context) to be significant main effects. Speech style was also a significant main effect although all other non-linguistic factors (i.e. age, ethnicity, speaker sex) were found to be non-significant. Nonetheless, all factors were kept in subsequent models for reasons described earlier and also because the non-significant factors had, in fact, significant interactions with other factors, both linguistic and non-linguistic. Table 4.7 shows the complete results from this analysis of variance.

Table 4.7: Analysis of Variance table of the full LME model of /r/ variants in all phonological positions in combined read and conversational speech (values rounded off to 3 decimal places), (n = 41,748).

Parameter	Sum Sq	Mean Sq	Num df	Den df	*F* Value	Pr(>*F*)	Sig.
Age	2.535	2.535	1	94	3.660	0.059	.
Ethnicity	5.239	1.746	3	89	2.521	0.063	.
Speaker sex	0.211	0.211	1	90	0.305	0.582	
Speech style	20.548	20.548	1	30031	29.663	5.182e-08	***
Phonological position	144.133	48.044	3	122	69.357	< 2.2e-16	***
Word class	13.359	13.359	1	9775	19.286	1.137e-05	***
Following context	160.285	13.357	12	5597	19.282	< 2.2e-16	***
Age:Ethnicity	7.337	2.446	3	88	3.531	0.018	*
Age:Speaker sex	0.633	0.633	1	89	0.914	0.342	
Age:Speech style	11.786	11.786	1	41422	17.014	3.718e-05	***
Age:Phonological position	4.196	1.399	3	93	2.019	0.117	
Age:Word class	3.733	3.733	1	41281	5.389	0.020	*
Ethnicity:Speaker sex	1.392	0.464	3	86	0.670	0.573	
Ethnicity:Speech style	34.850	11.617	3	40351	16.770	6.966e-11	***
Ethnicity:Phonological position	19.520	2.169	9	89	3.131	0.003	**
Ethnicity:Word class	17.039	5.680	3	41360	8.199	1.881e-05	***
Speaker sex:Speech style	4.762	4.762	1	41035	6.875	0.009	**
Speaker sex:Phonological position	15.721	5.240	3	93	7.565	< 0.001	***
Speaker sex:Word class	12.453	12.453	1	41330	17.977	2.241e-05	***
Speech style:Phonological position	100.712	33.571	3	5454	48.463	< 2.2e-16	***
Phonological position:Word class	15.642	5.214	3	4909	7.527	5.055e-05	***

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$, '.' $p < 0.1$

Although levels of significance for each parameter can be derived from this analysis of variance, nothing can be told of what happens at specific levels of these multi-level parameters (e.g. Reading versus Conversation in the 'Speech style' parameter). Therefore, parameter-specific *p*-values were subsequently generated from the *summary* function in the same lmerTest package (Kuznetsova et al., 2016) in R (R Core Team, 2016). Only parameters which were found to be significant are presented in Table 4.8.

Table 4.8: Significant fixed effects and interactions (parameter-specific) for the full LME model of /r/ variants in all phonological positions in combined read and conversational speech (values rounded off to 3 decimal places), (n = 41,748).

Parameter	**Estimate**	**Std. Error**	**t Value**	**df**	**Pr(>|t|)**	**Sig.**
(Intercept)	1.323	0.269	4.915	148	2.325e-06	***
Age	-0.027	0.009	-2.986	139	0.003	**
Ethnicity (Eurasian)	-0.655	0.317	-2.066	109	0.041	*
Ethnicity (Malay)	-0.775	0.366	-2.114	101	0.037	*
Speech style (Reading)	0.123	0.048	2.545	28705	0.011	*
Phonological position (Syllable-initial)	2.224	0.258	8.634	102	8.704e-14	***
Phonological position (Syllable-initial consonant cluster)	2.457	0.217	11.323	103	< 2e-16	***
Phonological position (Intervocalic)	2.774	0.207	13.397	103	< 2e-16	***
Word class (Function)	-0.173	0.046	-3.752	31526	1.76e-04	***
Following context (Pause)	-0.412	0.056	-7.381	3696	1.927e-13	***
Following context (Affricate)	-0.474	0.075	-6.356	5828	2.228e-10	***
Following context (High back)	-0.265	0.058	-4.556	5576	5.335e-06	***
Following context (Fricative)	-0.506	0.048	-10.458	3962	< 2e-16	***
Following context (Glide)	-0.452	0.059	-7.661	5344	2.176e-14	***
Following context (High front)	-0.233	0.043	-5.395	3592	7.287e-08	***

Following context (Liquid)	-0.508	0.059	-8.651	4013	< 2e-16	***
Following context (Low back round)	-0.228	0.059	-3.850	4377	1.20e-04	***
Following context (Low front)	-0.111	0.049	-2.271	4154	0.023	*
Following context (Nasal)	-0.473	0.057	-8.237	4579	2.22e-16	***
Following context (Stop)	-0.480	0.049	-9.866	3978	< 2e-16	***
Age : Ethnicity (Eurasian)	0.024	0.010	2.488	89	0.015	*
Age : Ethnicity (Malay)	0.034	0.012	2.849	90	0.005	**
Age : Speech style (Reading)	0.006	0.001	4.125	41422	3.718e-04	***
Age : Phonological position (Syllable-initial)	0.016	0.008	2.023	97	0.046	*
Age : Phonological position (Syllable-initial consonant cluster)	0.014	0.007	2.014	97	0.047	*
Age : Word class (Function)	0.003	0.001	2.321	41281	0.020	*
Ethnicity (Eurasian) : Speech style (Reading)	-0.132	0.029	-4.467	40167	7.957e-06	***
Ethnicity (Malay) : Speech style (Reading)	-0.155	0.030	-5.218	38559	1.816e-07	***
Ethnicity (Indian) : Speech style (Reading)	-0.205	0.030	-6.803	40200	1.036e-11	***
Ethnicity (Indian) : Phonological position (Syllable-initial)	0.395	0.182	2.165	96	0.033	*
Ethnicity (Eurasian) : Phonological position (Intervocalic)	0.288	0.142	2.028	92	0.045	*
Ethnicity (Indian) : Phonological position (Intervocalic)	0.321	0.144	2.223	92	0.029	*

Ethnicity (Eurasian) : Word class (Function)	0.103	0.027	3.772	41388	1.62e-04	***
Ethnicity (Indian) : Word class (Function)	0.114	0.028	4.065	41363	4.805e-05	***
Speaker sex (Male) : Speech style (Reading)	-0.055	0.021	-2.622	41035	0.009	**
Speaker sex (Male) : Phonological position (Syllable-initial)	0.570	0.123	4.618	97	1.191e-05	***
Speaker sex (Male) : Phonological position (Syllable-initial consonant cluster)	0.327	0.104	3.153	97	0.002	**
Speaker sex (Male) : Phonological position (Intervocalic)	0.401	0.098	4.088	95	9.127e-05	***
Speaker sex (Male) : Word class (Function)	-0.084	0.020	-4.240	41330	2.241e-05	***
Speech style (Reading) : Phonological position (Syllable-initial)	-0.293	0.054	-5.463	3394	5.008e-08	***
Speech style (Reading) : Phonological position (Syllable-initial consonant cluster)	-0.460	0.039	-11.718	10195	< 2e-16	***
Speech style (Reading) : Phonological position (Intervocalic)	-0.151	0.062	-2.441	5843	0.015	*
Phonological position (Syllable-initial consonant cluster) : Word class (Function)	-0.335	0.077	-4.366	2488	1.320e-05	***

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

While both levels of LME analysis show similar results, the summary, as seen in Table 4.8, provides finer details of individual levels within each parameter. For example, in the preliminary analysis of variance (see Table 4.7), the non-linguistic factor of ethnicity is found to have a marginally significant ($p < .1$) overall effect on /r/ realisation. Further information is then revealed in the summary as presented in Table 4.8; ethnically Eurasian and Malay SgE speakers behave significantly differently ($p < .05$) from those in the reference ethnicity level - ethnically Chinese SgE speakers. Similarly, in addition to the fact that the linguistic factor of following context is shown in Table 4.7 to have a significant overall effect ($p < .001$) on /r/ realisation, parameter-specific results are seen in Table 4.8. It shows that the effects of all other following contexts, except low back unrounded vowels, on /r/ realisation are significantly different from that of the reference level of following context – mid-central vowel. It is clear then that some deeper level of understanding can be derived from this analysis. However, due to the fact that there are many multilevel parameters and, more importantly, that the outcome variable (i.e. /r/ score) these parameters have effects on is multinomial and not binomial or a continuous ordinal one, the discussions of factors and interactions remain complicated and the interpretation of coefficients/estimates challenging. It is acknowledged that the interpretation of LME results can be improved with visualisation of effects using plotting (e.g. effects package in R), but, in this study, emphasis is placed on main interpretation based on the visualisation of multinomial linear regression (MLR) results from predicted probabilities instead. The reasons for this choice and the process in which the interpretation of results was done will be further explained next.

A similar complexity can be said of interpreting coefficients obtained from an MLR model. The MLR analysis involved exactly the same maximally-fitted model (i.e. same fixed effects and interactions) as the LME analysis. Table 4.9, which has been generated using the *htmlreg* function in the texreg package (Leifeld, 2016) in R (R Core Team, 2016), presents the coefficients, standard errors and significance of each level of the outcome variable (i.e. each /r/ score except the reference level, /r/ score 4) for every level (except the reference levels) of all parameters derived from the MLR model. This undeniably gives a clearer picture of where the effects lie within the multinomial outcome variable and facilitates the discussion of the effects of linguistic and non-linguistic factors within individual levels of the outcome variable. For example, the negative coefficients for '(Intercept)' indicate that there are generally lower likelihoods of all other /r/ scores (i.e. Scores 5, 3, 2, 1, 0) occurring than Score 4 (reference level) in relation to all the other reference levels of the various parameters. When further focusing specifically on 'Speech style', it can be interpreted that the log odds of Score 5 occurring is 4.09 less than that of Score 4 ($p < .001$) when in conversational speech (reference level). The negative coefficient (i.e. -1.78^{**}) for 'Speech style (Reading)' in the Score 5 column then indicates that in read speech the log odds of Score 5 occurrences (i.e. 4.09 less than Score 4) decreases further by 1.78 ($p < .01$). Thus, the log odds of Score 5 occurring is 5.87 (i.e. 4.09 + 1.78) less than that of Score 4 when in read speech, ceteris paribus. This provides evidence that Score 5 is more likely to occur in conversation than in reading although one should be mindful that this is true only in the reference levels of the other parameters and is also in comparison to the likelihood of Score 4 occurrence in that particular context. Due to the multilevel, multinomial nature of the model, working with coefficients generated through MLR can get complicated, and even more so when making comparisons of effects amongst levels of the outcome variable (i.e. /r/ score) and interpreting interactions between factors.

Table 4.9: Results of the full MLR model of /r/ variants in all phonological positions in combined read and conversational speech, (n = 41,748). Estimated coefficients are given with standard errors in parentheses below. (Intercept) represents the following: Ethnicity (Chinese), Speaker sex (Female), Speech style (Conversation), Phonological position (Syllable-final), Word class (Content), Following context (Mid-central).

Parameter	**/r/ score**				
	5	**3**	**2**	**1**	**0**
(Intercept)	-4.09*** (1.11)	-2.08*** (0.60)	-3.33** (1.03)	-5.90*** (1.42)	-1.29*** (0.34)
Age	0.02 (0.04)	-0.00 (0.02)	-0.00 (0.03)	0.05 (0.05)	0.10*** (0.01)
Ethnicity (Eurasian)	0.72 (1.33)	0.40 (0.42)	1.72** (0.59)	0.29 (0.91)	3.15*** (0.32)
Ethnicity (Malay)	-1.83 (0.97)	-0.30 (0.44)	2.20*** (0.60)	3.63*** (0.87)	3.70*** (0.34)
Ethnicity (Indian)	-0.59 (0.93)	-0.51 (0.45)	1.09 (0.57)	1.26 (0.94)	-0.16 (0.33)
Speaker sex (Male)	-2.01** (0.72)	-0.66 (0.34)	-0.47 (0.49)	3.98*** (0.71)	1.75*** (0.28)
Speech style (Reading)	-1.78** (0.67)	0.43 (0.36)	-0.89 (0.46)	-0.84 (0.72)	-1.07*** (0.24)

Phonological position (Syllable-initial)	-1.87 (1.21)	0.19 (0.62)	2.54* (1.02)	-2.86 (2.11)	-5.46*** (0.66)
Phonological position (Syllable-initial consonant cluster)	-1.07 (0.95)	1.68** (0.54)	1.89 (1.01)	0.63 (1.33)	-3.83*** (0.34)
Phonological position (Intervocalic)	-1.90 (1.13)	0.30 (0.63)	-0.06 (1.03)	-6.16*** (1.63)	-4.26*** (0.51)
Word class (Function)	0.41 (0.70)	-0.71* (0.32)	-0.38 (0.50)	1.92** (0.64)	0.54* (0.21)
Following context (Pause)	-0.01 (0.76)	-0.01 (0.36)	1.38* (0.56)	0.03 (1.19)	2.19*** (0.13)
Following context (Affricate)	-0.81 (2.90)	-0.16 (0.87)	2.15* (0.93)	0.69 (2.64)	2.93*** (0.28)
Following context (High back)	1.03*** (0.24)	-0.70*** (0.13)	0.69*** (0.14)	0.26 (0.27)	0.81*** (0.21)
Following context (Fricative)	0.27 (0.53)	-0.18 (0.30)	0.75 (0.57)	0.99 (0.73)	2.46*** (0.11)
Following context (Glide)	-0.61 (1.46)	-1.00 (1.01)	1.54 (0.85)	0.91 (1.38)	2.38*** (0.22)
Following context (High front)	-0.29 (0.19)	-0.52*** (0.08)	0.87*** (0.10)	0.32 (0.21)	0.49*** (0.09)
Following context (Liquid)	-0.16 (0.94)	-1.38 (0.71)	0.69 (0.86)	1.80* (0.76)	2.29*** (0.15)
Following context (Low back rounded)	-1.47*** (0.35)	-1.40*** (0.12)	-1.06*** (0.17)	-0.21 (0.24)	1.63*** (0.13)
Following context (Low back unrounded)	-0.44* (0.22)	-0.95*** (0.09)	-0.23* (0.11)	0.06 (0.22)	0.41*** (0.11)
Following context (Low front)	0.24 (0.21)	-1.08*** (0.10)	-0.11 (0.12)	0.07 (0.23)	0.94*** (0.12)
Following context (Nasal)	-1.46 (2.00)	-1.90 (1.14)	0.36 (1.13)	0.27 (1.62)	2.36*** (0.17)
Following context (Stop)	0.57 (0.43)	-0.89** (0.32)	-0.16 (0.66)	1.67** (0.57)	1.94*** (0.10)

Age : Ethnicity (Eurasian)	-0.09*	-0.02*	-0.09***	-0.04*	-0.11***
	(0.04)	(0.01)	(0.01)	(0.02)	(0.01)
Age : Ethnicity (Malay)	-0.00	-0.03**	-0.13***	-0.14***	-0.17***
	(0.03)	(0.01)	(0.01)	(0.02)	(0.01)
Age : Ethnicity (Indian)	-0.00	-0.01	-0.08***	-0.11***	-0.02
	(0.03)	(0.01)	(0.01)	(0.02)	(0.01)
Age : Speaker sex (Male)	0.12***	0.02**	0.01	-0.09***	-0.04***
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
Age : Speech style (Reading)	0.03	-0.00	-0.01	-0.02	-0.00
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
Age : Phonological position (Syllable-initial)	-0.01	0.01	0.03	-0.00	-0.02
	(0.03)	(0.02)	(0.03)	(0.06)	(0.02)
Age : Phonological position (Syllable-initial consonant cluster)	-0.02	0.01	0.03	0.03	-0.06***
	(0.02)	(0.02)	(0.03)	(0.04)	(0.01)
Age : Phonological position (Intervocalic)	-0.00	-0.02	0.07*	0.15**	-0.03*
	(0.03)	(0.02)	(0.03)	(0.05)	(0.02)
Age : Word class (Function)	-0.01	0.03***	0.00	-0.05***	-0.01
	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)
Ethnicity (Eurasian) : Speaker sex (Male)	0.45	-0.09	0.60***	-0.74*	-0.49**
	(0.78)	(0.15)	(0.13)	(0.30)	(0.16)
Ethnicity (Malay) : Speaker sex (Male)	2.18***	0.94***	0.50***	-0.91**	-0.15
	(0.46)	(0.14)	(0.14)	(0.31)	(0.15)
Ethnicity (Indian) : Speaker sex (Male)	-0.49	0.72***	1.45***	1.28***	1.37***
	(0.48)	(0.16)	(0.16)	(0.31)	(0.20)
Ethnicity (Eurasian) : Speech style (Reading)	0.67	0.09	0.87***	1.11**	0.47**
	(0.71)	(0.15)	(0.12)	(0.36)	(0.16)
Ethnicity (Malay) : Speech style (Reading)	1.90***	0.59***	0.41***	0.79*	0.87***
	(0.48)	(0.15)	(0.12)	(0.37)	(0.15)
Ethnicity (Indian) : Speech style (Reading)	0.05	0.04	1.13***	1.35***	0.57***
	(0.48)	(0.16)	(0.14)	(0.38)	(0.16)

Ethnicity (Eurasian): Phonological position (Syllable-initial)	-1.15 (2.42)	-0.07 (0.37)	-0.15 (0.55)	0.29 (1.50)	-0.07 (0.39)
Ethnicity (Malay): Phonological position (Syllable-initial)	3.50*** (0.82)	0.10 (0.32)	0.05 (0.54)	0.42 (1.18)	0.39 (0.36)
Ethnicity (Indian): Phonological position (Syllable-initial)	4.17*** (0.87)	-0.42 (0.42)	-0.87 (0.51)	3.25** (1.15)	-0.70 (0.42)
Ethnicity (Eurasian): Phonological position (Syllable-initial consonant cluster)	0.46 (0.76)	-0.01 (0.32)	-0.03 (0.55)	-0.25 (0.74)	0.03 (0.19)
Ethnicity (Malay): Phonological position (Syllable-initial consonant cluster)	1.70** (0.53)	0.64* (0.28)	0.94 (0.53)	-0.77 (0.55)	0.74*** (0.18)
Ethnicity (Indian): Phonological position (Syllable-initial consonant cluster)	1.54* (0.62)	0.25 (0.36)	-1.05* (0.51)	-0.46 (0.70)	-0.22 (0.22)
Ethnicity (Eurasian): Phonological position (Intervocalic)	1.08 (1.03)	-0.13 (0.38)	-0.40 (0.57)	-0.01 (0.95)	-1.22*** (0.30)
Ethnicity (Malay): Phonological position (Intervocalic)	2.85*** (0.76)	0.44 (0.33)	0.57 (0.54)	0.64 (0.77)	-0.54 (0.28)
Ethnicity (Indian): Phonological position (Intervocalic)	3.91*** (0.81)	0.30 (0.41)	-1.39* (0.54)	0.93 (0.88)	-1.02** (0.33)
Ethnicity (Eurasian) : Word class (Function)	0.73 (0.66)	0.03 (0.17)	0.12 (0.20)	0.18 (0.28)	-0.51*** (0.15)
Ethnicity (Malay) : Word class (Function)	0.43 (0.48)	0.01 (0.16)	0.30 (0.18)	0.07 (0.28)	-0.26* (0.13)
Ethnicity (Indian) : Word class (Function)	1.26** (0.47)	0.02 (0.18)	0.27 (0.24)	0.92** (0.30)	-0.58*** (0.15)
Speaker sex (Male) : Speech style (Reading)	-1.49*** (0.25)	-0.07 (0.11)	0.31** (0.10)	-0.32 (0.28)	0.22 (0.13)
Speaker sex (Male) : Phonological position (Syllable-initial)	-1.10* (0.47)	-0.68* (0.28)	-1.53*** (0.44)	-2.87** (0.93)	-1.00*** (0.28)
Speaker sex (Male) : Phonological position (Syllable-initial consonant cluster)	-0.20 (0.44)	-0.24 (0.24)	-1.10* (0.44)	-1.02* (0.49)	-0.63*** (0.14)

Speaker sex (Male) : Phonological position (Intervocalic)	-0.42 (0.47)	-0.46 (0.28)	-0.95* (0.45)	-0.54 (0.62)	-1.33*** (0.23)
Speaker sex (Male) : Word class (Function)	-0.49* (0.25)	0.11 (0.13)	0.12 (0.16)	-0.56** (0.21)	0.16 (0.11)
Speech style (Reading) : Phonological position (Syllable-initial)	0.16 (0.47)	0.28 (0.33)	0.66 (0.42)	2.84** (1.06)	0.70* (0.29)
Speech style (Reading) : Phonological position (Syllable-initial consonant cluster)	1.63*** (0.45)	0.30 (0.29)	0.65 (0.42)	2.89*** (0.48)	0.54*** (0.14)
Speech style (Reading) : Phonological position (Intervocalic)	0.18 (0.48)	0.28 (0.33)	0.66 (0.43)	1.28* (0.65)	0.51 (0.26)
Phonological position (Syllable-initial) : Word class (Function)	0.17 (0.55)	-2.75** (1.02)	-0.99* (0.46)	-1.77 (1.84)	-0.28 (0.69)
Phonological position (Syllable-initial consonant cluster) : Word class (Function)	0.97* (0.44)	0.24 (0.23)	0.16 (0.42)	0.91 (0.49)	2.09*** (0.15)
Phonological position (Intervocalic) : Word class (Function)	-0.52 (0.48)	1.21*** (0.29)	-0.30 (0.44)	2.62*** (0.67)	2.37*** (0.24)

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

Thus, to enable more qualitative and systematic analyses for a comprehensive discussion of generalisable patterns in the /r/ realisation of SgE, predicted probabilities from the MLR models, instead of coefficients, were used. An extracted section of the entire table of predicted probabilities which were generated from the full MLR model using the *predict* function in the nnet package (Ripley & Venables, 2016) in R (R Core Team, 2016), is shown in Table 4.10. From this, it can be concluded, for example, that there is a much higher probability of a 17 year-old Eurasian female SgE speaker producing a strong post-alveolar approximant (i.e. Score 4; 55.2%) than a tap/trill (i.e. Score 5; 0.3%) for an intervocalic /r/ token followed by a mid-central vowel in a function word while reading. Additionally, there is also evidence that, for a function word in read speech, there is a higher chance of a speaker of this profile producing a strong labiodental approximant (i.e. Score 2) for a /r/ token in intervocalic position followed by a high front vowel (10.5%) than one followed by a low back rounded vowel (1.5%). It is therefore clear that cross comparisons of different factors and levels within factors are possible with predicted probabilities. Levels of significance of the differences between these predicted probabilities, however, are not available. On the other hand, as described earlier, although obtaining levels of factor significance from both the LME and MLR models is possible, there is often no realistic way of interpreting the *p*-values in validation of the predicted probabilities as they involve too many different levels of comparisons. A point to note here is that statistical models are fundamentally for the prediction of outcomes and, according to Gelman and Hill (2007), to exclude factors just because they fail slightly to reach the conventional significance levels would be erroneously saying that they definitely have zero effect on the outcome variable. Therefore, considering the described limitations and the fact that *caveats* have been expressed with regards to the sole reliance on *p*-values in the interpretation of results, predicted probabilities was chosen as the main medium of results analysis and presentation for this study. Predicted probabilities, which will aid in the interpretation of the effects of linguistic and non-linguistic factors as well as the interactions between them, will be presented mainly in the form of bar graphs, as done for the full model illustrated in Figure 4.17 for example. They will be further supported by factor significance from both the MLR and LME models only if applicable.

Table 4.10: Excerpt of a predicted probabilities table, generated from the MLR model (full model), of /r/ variants in all phonological positions in combined read and conversational speech (values rounded off to 3 decimal places). Factor codes: 'f' – Female, 'iv' – Intervocalic, 'F' – Function word.

Age	**Speaker sex**	**Ethnicity**	**Speech style**	**Phonological position**	**Word class**	**Following context**	**/r/ score**					
							5	**4**	**3**	**2**	**1**	**0**
17	f	Eurasian	reading	iv	F	mid-central	0.003	0.552	0.324	0.043	0.010	0.068
17	f	Eurasian	reading	iv	F	high back	0.008	0.568	0.166	0.088	0.013	0.157
17	f	Eurasian	reading	iv	F	high front	0.002	0.567	0.198	0.105	0.014	0.114
17	f	Eurasian	reading	iv	F	low back rounded	0.001	0.551	0.080	0.015	0.008	0.346
17	f	Eurasian	reading	iv	F	low front	0.004	0.622	0.124	0.043	0.012	0.195
17	f	Eurasian	reading	iv	F	low back unrounded	0.002	0.669	0.151	0.041	0.012	0.124

The MLR results as seen in Figure 4.17 pattern rather similarly to those obtained from the descriptive statistical analyses in Section 4.2. The majority of /r/ tokens in syllable-final positions are null realisations (i.e. Score 0) as represented by the lightest shade of blue in the figure. This observation is supported by the various analyses of significance, bearing in mind the limitations as discussed. Phonological position was found to have a highly significant effect on /r/ realisation (p < 2.2e-16) in the LME analysis of variance (see Table 4.7) and all other non-syllable-final phonological positions (i.e. syllable-initial, syllable-initial consonant clusters, intervocalic) have significantly different effects on /r/ realisation as compared to the syllable-final position (see Table 4.8). More specifically, the coefficients from the MLR model as presented in Table 4.9 indicate that these non-syllable-final positions are significantly less likely to have null realisations (i.e. Score 0) as compared to syllable-final positions ($p < .001$). When /r/ is realised, however, in both non-syllable-final and syllable-final positions, it is most commonly a strong post-alveolar approximant (i.e. Score 4). What surfaces here is the fact that although ethnically Malay male and female SgE speakers have almost equal probabilities of realising /r/ in syllable-final positions, /r/ realisations for females are mostly strong post-alveolar approximants (i.e. Score 4) while those for males are almost as often taps/trills (i.e. Score 5) as they are strong post-alveolar approximants (i.e. Score 4). Another observation from Figure 4.17 that is similar to patterns discussed in the descriptive statistical analyses is that, amongst the four ethnic groups, ethnically Chinese SgE speakers generally have the highest probability of producing perceptually weaker /r/ variants (i.e. lower /r/ scores – Scores 0, 1, 2) and the lowest probability of producing perceptually stronger /r/ variants (i.e. high /r/ scores – Scores 3, 4, 5), and the exact opposite pattern is true for ethnically Indian SgE speakers. While this is the case for female SgE speakers, there is a slight difference for male SgE speakers; particularly evident in male Indian SgE speakers. This will be further discussed in Section 4.4.5; once again highlighting not only the need for the consideration of linguistic and non-linguistic factors and the effects they have on /r/ realisation in SgE but also the level of interactions between these factors.

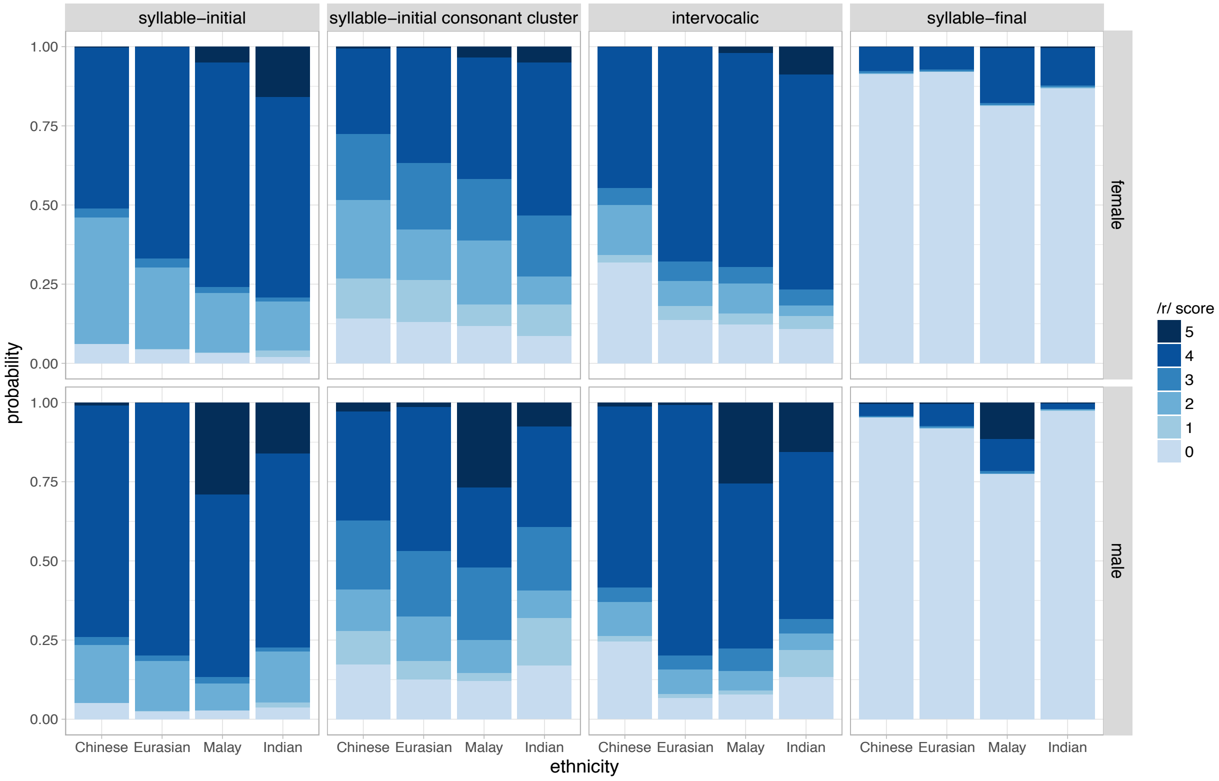

Figure 4.17: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in combined speech data, according to ethnicity, phonological position (presented in four columns, left to right – syllable-initial, syllable-initial consonant cluster, intervocalic, syllable-final), and speaker sex (presented in two rows; top – female, bottom – male), (*n* = 41,748).

What follows in the subsequent sections of this chapter is a presentation of the effects of linguistic factors, those of speech style and finally those of interactions between factors. Non-syllable-final and syllable-final /r/ realisations will be presented separately to aid in reducing unnecessary complicated levels of competing factors and facilitates a more systematic understanding of the complex multidimensional nature of /r/ realisations in SgE.

4.4 Variation in non-syllable-final /r/ realisations

4.4.1 Phonological position

Based on the results of the LME model as presented in Table 4.7, all linguistic factors (i.e. phonological position, word class, following context) have significant effects on /r/ realisation in SgE. Thus, these effects were first investigated, starting with phonological position. Both an MLR and an LME model were fitted to the data which included only non-syllable-final /r/ tokens from both read and conversational speech. The models here had the same fixed and random effects structures, wherever applicable, and were also analysed in the same ways as the full model, as described in Section 4.3.2. Plotted in Figure 4.18 are the predicted probabilities, as derived from the MLR model, of the occurrence of each /r/ variant (i.e. Scores 5 – 0) in each of the three non-syllable-final phonological positions.

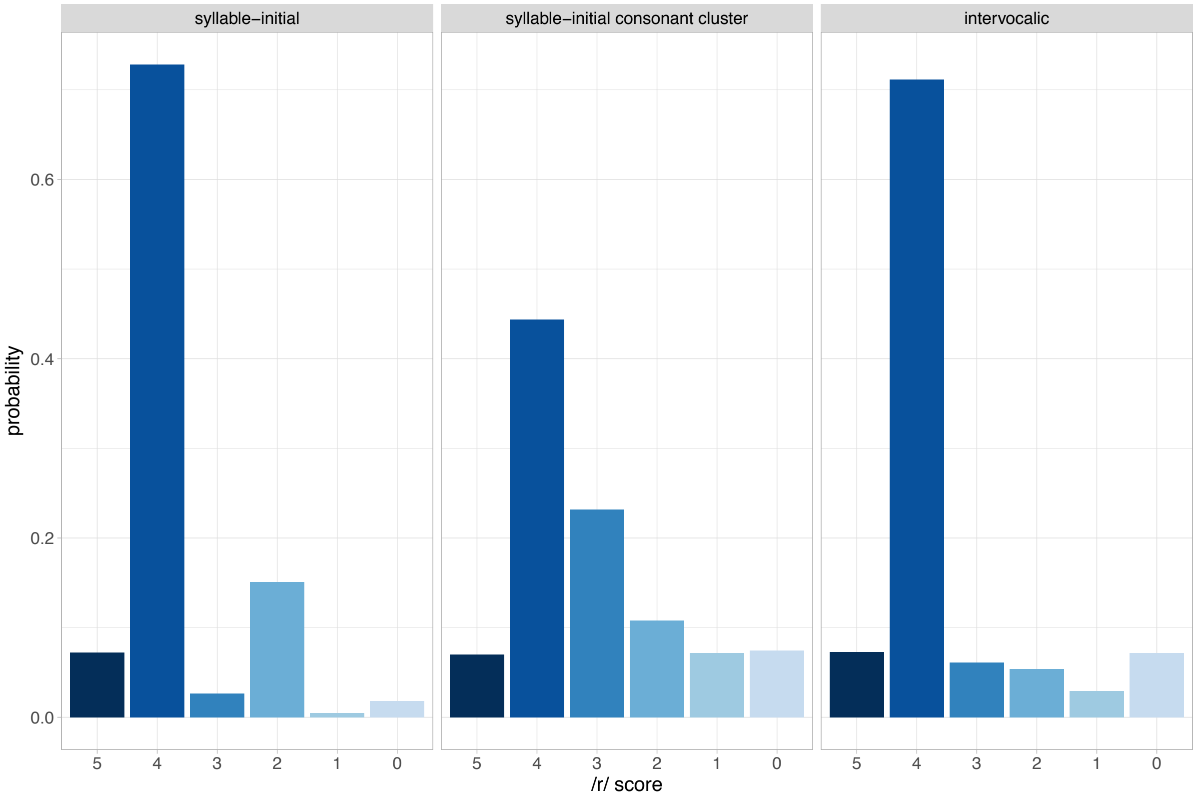

Figure 4.18: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in combined speech styles, according to non-syllable-final phonological position (presented in three columns, left to right – syllable-initial, syllable-initial consonant cluster, intervocalic), (n = 17,886).

It appears that there is most variation from Score 4 (i.e. strong post-alveolar approximant), the prescriptive /r/ realisation in SgE, when /r/ occurs in syllable-initial consonant clusters. The predicted probability of producing the most dominant /r/ variant in SgE (i.e. Score 4 – strong post-alveolar approximant) is observably lower in syllable-initial consonant clusters (e.g. *probably*) than in syllable-initial (e.g. *rather*) and intervocalic positions (e.g. *Morocco*). Conversely, the predicted probabilities of producing most of the other perceptually weaker /r/variants (i.e. Score 0 – null realisation, Score 1 – weak labiodental approximant, and Score 3 – weak post-alveolar approximant) are higher in syllable-initial consonant clusters than syllable-initially and intervocalically. This hints at the possibility of syllable-initial consonant clusters promoting a process of /r/ weakening in SgE. If this holds true, the predicted probability of tap/trill (i.e. Score 5) occurrences would be the lowest in syllable-initial consonant clusters and the predicted probability of strong labiodental approximant (i.e. Score 2) occurrences would be in complementary relationships with those of weak labiodental approximant (i.e. Score 1) and strong post-alveolar approximant (i.e. Score 4) occurrences. Analysing the occurrences of the tap/trill (i.e. Score 5), there appears to be relatively equal predicted probabilities of taps/trills (i.e. Score 5) occurring in all three phonological positions, although the predicted probability of their occurrence in syllable-initial consonant clusters is indeed the lowest. Differing from its perceptually weaker variant (i.e. Score 1 – weak labiodental approximant), the strong labiodental approximant (i.e. Score 2) does not occur most frequently in syllable-initial consonant clusters. It, in fact, occurs most frequently in syllable-initial position, as does its post-alveolar counterpart (i.e. Score 4 – strong post-alveolar approximant) (e.g. *really*, *rock*). Additionally, while the predicted probability of the strong post-alveolar approximant (i.e. Score 4) occurring in syllable-initial consonant clusters is the lowest amongst the three non syllable-final phonological positions, there is a higher predicted probability of the strong labiodental approximant (i.e. Score 2) occurring in syllable-initial consonant clusters than intervocalically. These patterns of tap/trill (i.e. Score 5), strong labiodental approximant (i.e. Score 2) and strong post-alveolar approximant (i.e. Score 4) occurrences therefore further support the hypothesis of syllable-initial consonant clusters promoting perceptually weaker /r/ realisations. Table 4.11 presents the predicted probabilities as illustrated in Figure 4.18.

Table 4.11: Average predicted probabilities (rounded off to 3 decimal places), generated from the MLR model, of /r/ variants for each non-syllable-final phonological position in combined speech styles.

Phonological position	**/r/ score**					
	5	**4**	**3**	**2**	**1**	**0**
syllable-initial	0.072	0.728	0.026	0.151	0.005	0.018
syllable-initial consonant cluster	0.070	0.444	0.232	0.108	0.072	0.074
intervocalic	0.073	0.712	0.061	0.054	0.029	0.071

The coefficients and standard errors as well as *p*-values derived from the MLR model provide further support for the significance of these observed differences among phonological positions. Displayed in Table 4.12 are the coefficients and significance, with standard errors in parentheses. Results show that the log odds of a null realisation (i.e. Score 0) versus a strong post-alveolar approximant (i.e. Score 4) realisation (log odds of -8.03, $p < .001$) increases by 2.93 ($p < .05$) if moving from a syllable-initial position to a syllable-initial consonant cluster. This supports the fact that null realisations (i.e. Score 0) are predicted to have a higher probability of occurrence in syllable-initial consonant clusters than syllable-initially. Moreover, the log odds of a null realisation (i.e. Score 0) versus a strong post-alveolar approximant (i.e. Score 4) realisation (log odds of -4.33, $p < .001$) reduces further by 0.6 (*n.s.*) if it occurs intervocalically instead of in a syllable-initial consonant cluster. It is, thus, evidenced that null realisations are, indeed, predicted to occur more often in syllable-initial consonant clusters (e.g. *probably*) than intervocalically (e.g. *courage*), albeit only very slightly with no significant difference found between the two. Similarly, there is also support for the higher predicted probabilities of producing the other perceptually weaker /r/ variants (i.e. Score 1 – weak labiodental approximant, Score 3 – weak post-alveolar approximant) in syllable-initial consonant clusters than in intervocalic positions. The log odds of producing a weak labiodental approximant (i.e. Score 1) versus a strong post-alveolar approximant (i.e. Score 4) (log odds of -9.34, $p < .001$) increases by 3.76 ($p < .001$) and that of producing a weak post-alveolar approximant (i.e. Score 3) versus a strong post-alveolar approximant (i.e. Score 4) (log odds of -3.34, $p < .001$) increases by 2.24 ($p < .001$) when moving from an intervocalic position to a syllable-initial consonant cluster. Additionally, the log odds of a weak post-alveolar approximant (i.e. Score 3) occurrence versus a strong post-alveolar approximant (i.e. Score 4) occurrence in syllable-initial position (log odds of -2.48, $p < .001$) also increases, by 1.47 ($p < .001$), when it is in a syllable-initial consonant cluster instead. It is acknowledged, however, that there are some conflicting results, and also non-significant effects, in the analysis of coefficients and also in the comparisons between predicted probabilities and coefficients for Scores 0, 1 and 3 (i.e. null realisation, weak labiodental approximant, weak post-alveolar approximant). This is a reflection of the implications of the multiple reference levels encompassed in the 'Intercept' value which were highlighted in Section 4.3.2. It could also be due to the effects of interactions with other factors, small number of tokens in the various levels within factors and/or the effects of individual speaker differences, as suggested by the high standard errors (i.e. numbers in parentheses in Table 4.12). The challenges of basing discussions of /r/ variation in SgE on the coefficients generated by the MLR model is reiterated and thus the robust evidence found through predicted probabilities in support of syllable-initial consonant clusters promoting perceptually weaker /r/ realisations is not undermined.

There is also supporting evidence for the observations gathered from the predicted probabilities of strong labiodental approximant (i.e. Score 2) occurrences. Here, the positive coefficient for Score 2 (reference level – intervocalic position, focus level – syllable-initial position) denotes that the log odds of realising a strong labiodental approximant (i.e. Score 2) versus a strong post-alveolar approximant (i.e. Score 4) (log odds of -3.98, $p < .001$) will increase by 2.54 ($p < .001$) if moving from an intervocalic position to a syllable-initial position. Similarly, it can be seen that the log odds of realizing a strong labiodental approximant (i.e. Score 2) versus a strong post-alveolar approximant (i.e. Score 4) also increases, by 1.38 ($p < .001$), when moving from an intervocalic position to a syllable-initial consonant cluster position. Together, these imply a significantly higher probability of both the syllable-initial (e.g. *ring*) and syllable-initial consonant cluster (e.g. *bring*) positions promoting a strong labiodental approximant (i.e. Score 2) than the intervocalic position (e.g. *caring*), verifying what has been observed in Figure 4.18.

Table 4.12: Coefficients, significance and standard errors (in parentheses), generated from the MLR model, of /r/ variants for non-syllable-final phonological positions in combined speech styles; reference level (/r/ score): Score 4.

Phonological position		**/r/ score**				
reference level	**focus level**	**5**	**3**	**2**	**1**	**0**
(Intercept)		-5.46*** (0.94)	-3.34*** (0.46)	-3.98*** (0.36)	-9.34*** (0.97)	-4.75*** (0.79)
intervocalic	syllable-initial	0.12 (0.74)	0.68 (0.50)	2.54*** (0.31)	2.08 (1.34)	-1.28 (1.10)
(Intercept)		-6.39*** (1.24)	-2.48*** (0.43)	-1.39*** (0.31)	-2.70*** (0.60)	-8.03*** (1.27)
syllable-initial	intervocalic	-0.30 (0.96)	-0.36 (0.50)	-2.18*** (0.30)	-8.65*** (0.74)	1.82 (1.32)
(Intercept)		-6.39*** (1.24)	-2.48*** (0.43)	-1.39*** (0.31)	-2.70*** (0.60)	-8.03*** (1.27)
syllable-initial	syllable-initial consonant cluster	-0.38 (0.96)	1.47*** (0.35)	-1.08*** (0.23)	-3.27*** (0.53)	2.93* (1.27)
(Intercept)		-5.37*** (0.93)	-1.04*** (0.32)	-2.50*** (0.30)	-5.89*** (0.75)	-4.33*** (0.74)
syllable-initial consonant cluster	syllable-initial	0.66 (0.68)	-1.43*** (0.35)	1.16*** (0.23)	-1.80 (1.16)	-1.88 (0.97)
(Intercept)		-5.37*** (0.93)	-1.04*** (0.32)	-2.50*** (0.30)	-5.89*** (0.75)	-4.33*** (0.74)
syllable-initial consonant cluster	intervocalic	-0.09 (0.71)	-2.24*** (0.39)	-1.07*** (0.31)	-3.44*** (0.86)	-0.60 (0.60)
(Intercept)		-5.46*** (0.94)	-3.34*** (0.46)	-3.98*** (0.36)	-9.34*** (0.97)	-4.75*** (0.79)
intervocalic	syllable-initial consonant cluster	0.31 (0.69)	2.24*** (0.40)	1.38*** (0.31)	3.76*** (0.85)	0.30 (0.60)

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

In the analysis of the realisation of the most dominant /r/-variant in SgE (i.e. Score 4 – strong post-alveolar approximant), the coefficients, standard errors and significance of differences derived from the MLR model are presented with the reference level for /r/ score as Score 0 (i.e. null realisation) instead, as seen in Table 4.13. The log odds of a strong post-alveolar approximant (i.e. Score 4) occurrence versus a null realisation (i.e. Score 0) in intervocalic position (log odds of 5.46, $p < .001$) decreases by 1.44 ($p < .01$) when moving to a syllable-initial consonant cluster. In a syllable-initial consonant cluster, however, the log odds of a strong post-alveolar approximant (i.e. Score 4) occurrence versus a null realisation (i.e. Score 0) (log odds of 4.46, $p < .001$) increases by 1.94 ($p < .05$) when moving to a syllable-initial position. This supports the conclusion that it is more likely for /r/ realisations to be strong post-alveolar approximants (i.e. Score 4) when in syllable-initial (e.g. *rather*) and intervocalic positions (e.g. *Morocco*) than when in syllable-initial consonant clusters (e.g. *probably*).

Table 4.13: Coefficients, significance and standard errors (in parentheses), generated from the MLR model, of /r/ variants for each non-syllable-final phonological position in combined speech styles; reference level (/r/ score): Score 0.

Phonological position		**/r/ score**
reference level	**focus level**	**4**
(Intercept)		4.99^{***} (0.59)
syllable-initial	intervocalic	0.03 (0.54)
(Intercept)		4.46^{***} (0.57)
syllable-initial consonant cluster	syllable-initial	1.94^{*} (0.80)
(Intercept)		5.46^{***} (0.61)
intervocalic	syllable-initial consonant cluster	-1.44^{**} (0.53)

Significance codes: ‘***’ $p < 0.001$, ‘**’ $p < 0.01$, ‘*’ $p < 0.05$

Phonological position is thus found to contribute to /r/ variation in SgE in the following ways:

- There is most variation in /r/ realisations when /r/ occurs in syllable-initial consonant clusters (e.g. *bring*).
- Taps/trills (i.e. Score 5) are least likely to occur when /r/ is in a syllable-initial consonant cluster (e.g. *bring*).
- Null realisations (i.e. Score 0), weak labiodental approximants (i.e. Score 1), and weak post-alveolar approximants (i.e. Score 3) are most likely to occur when /r/ is in a syllable-initial consonant cluster (e.g. *bring*).
- Strong labiodental approximants (i.e. Score 2) and strong post-alveolar approximants (i.e. Score 4) are most likely to occur when /r/ is in syllable-initial position (e.g. *ring*).
- Strong labiodental approximants (i.e. Score 2) are more likely to occur when /r/ is in a syllable-initial consonant cluster (e.g. bring) than when /r/ is in intervocalic position (e.g. *caring*) but strong post-alveolar approximants (i.e. Score 4) are more likely to occur when /r/ is in intervocalic position than when /r/ is in a syllable-initial consonant cluster.

Taking these findings together, evidence is shown for the effects of syllable-initial consonant clusters promoting perceptually weaker /r/ realisations and of syllable-initial phonological positions promoting perceptually stronger ones. This applies to a comparison of /r/ variants on the entire index (i.e. Scores 0 – 5) as well as between the weak and strong realisations of both variants of approximant /r/ (i.e. Score 1 vs. Score 2, Score 3 vs. Score 4).

4.4.2 Word class

In addition to phonological position, word class (i.e. content words and function words) was also found to have significant overall effects on /r/ realisation in SgE. A general study of word class effects alone shows that regardless of phonological position, there is a significantly higher predicted probability of null realisations (i.e. Score 0) occurring in function words (e.g. *around*) than in content words (e.g. *arrive*). This is illustrated in Figure 4.19 and Table 4.14 which present the predicted probabilities generated from the same MLR model as done for phonological position reported in Section 4.4.1. Further evidence is also seen in the results of the MLR analysis presented in Table 4.15, which show that the log odds of producing a null realisation (i.e. Score 0) versus a strong post-alveolar approximant (i.e. Score 4) in all three non-syllable-final phonological positions increase when moving from a content word to a function word ($p < .001$). There is also a higher predicted probability of taps/trills (i.e. Score 5) occurring in function words than in content words. Predicted probabilities show this word class effect to be true across all non-syllable-final phonological positions, with significance found only for syllable-initial consonant clusters (e.g. *through*) in which the effect is the strongest; the log odds of producing a tap/trill (i.e. Score 5) versus a strong post-alveolar approximant (i.e. Score 4) in syllable-initial consonant clusters (log odds of -5.37, $p < .001$) increases by 1.48 ($p < .05$) when it occurs in a function word instead of a content word. For strong labiodental approximants (i.e. Score 2), the effect was in the reverse direction. Strong labiodental approximants (i.e. Score 2) occur more in content words (e.g. *favourite*) than in function words (e.g. *every*) across all non-syllable-final phonological positions. While there are effects of other reference levels in factor significance generated for strong labiodental approximants (i.e. Score 2) occurrences, there also lies a chance of a wide range of behaviours amongst SgE speakers for this /r/ variant, as implied by high standard errors and non-significance. These findings should therefore be interpreted with caution.

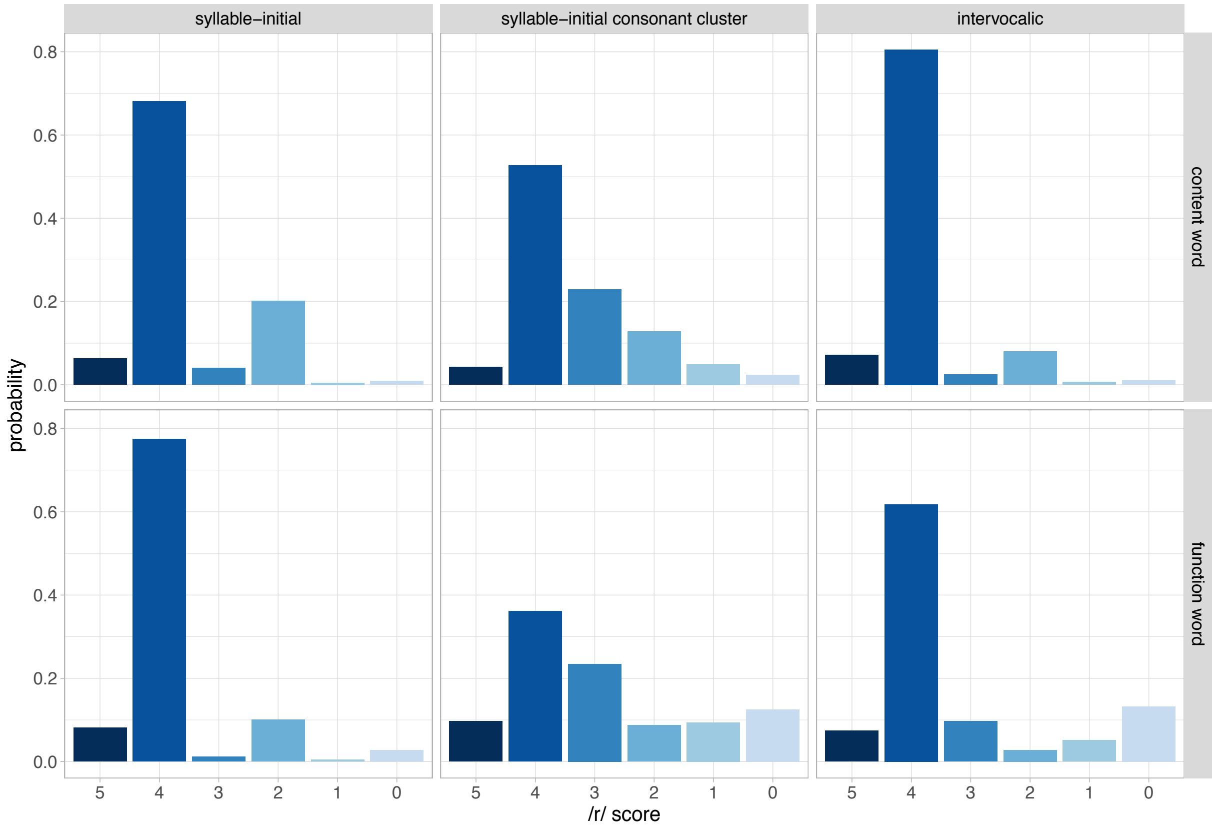

Figure 4.19: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in combined speech styles, according to non-syllable-final phonological position (presented in three columns, left to right – syllable-initial, syllable-initial consonant cluster, intervocalic), and word class (presented in two rows; top – content word, bottom – function word), (n = 17,886).

Table 4.14: Average predicted probabilities (rounded off to 3 decimal places), generated from the MLR model, of /r/ variants for each non-syllable-final phonological position and each word class in combined speech styles.

Phonological position	**Word class**	**/r/ score**					
		5	**4**	**3**	**2**	**1**	**0**
syllable-initial	content	0.063	0.681	0.041	0.201	0.005	0.009
	function	0.081	0.775	0.012	0.100	0.004	0.027
syllable-initial consonant cluster	content	0.043	0.527	0.229	0.129	0.049	0.024
	function	0.097	0.361	0.235	0.088	0.094	0.125
intervocalic	content	0.072	0.805	0.025	0.080	0.007	0.010
	function	0.074	0.618	0.097	0.028	0.051	0.132

Table 4.15: Coefficients, significance and standard errors (in parentheses), generated from the MLR model, of /r/ variants for word form in combined speech styles, according to non-syllable-final phonological positions; reference level (/r/ score): Score 4.

Syllable-initial						
Word class		**/r/ score**				
reference level	**focus level**	**5**	**3**	**2**	**1**	**0**
(Intercept)		-6.39^{***} (1.24)	-2.48^{***} (0.43)	-1.39^{***} (0.31)	-2.70^{***} (0.60)	-8.03^{***} (1.27)
content word	function word	0.84 (0.89)	-1.48^{*} (0.68)	-0.64 (0.40)	0.97^{*} (0.39)	3.71^{***} (0.97)

Syllable-initial consonant cluster						
Word class		**/r/ score**				
reference level	**focus level**	**5**	**3**	**2**	**1**	**0**
(Intercept)		-5.37^{***} (0.93)	-1.04^{***} (0.32)	-2.50^{***} (0.30)	-5.89^{***} (0.75)	-4.33^{***} (0.74)
content word	function word	1.48^{*} (0.64)	0.44 (0.28)	0.35 (0.35)	1.86^{***} (0.46)	2.24^{***} (0.51)

Intervocalic						
Word class		**/r/ score**				
reference level	**focus level**	**5**	**3**	**2**	**1**	**0**
(Intercept)		-5.46^{***} (0.94)	-3.34^{***} (0.46)	-3.98^{***} (0.36)	-9.34^{***} (0.97)	-4.75^{***} (0.79)
content word	function word	0.16 (0.67)	1.89^{***} (0.33)	-0.30 (0.39)	3.16^{***} (0.60)	2.84^{***} (0.54)

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

Further analysis of word class was built on the preceding discussion of phonological position and investigated the possible differences between content words and function words for each /r/ variant across non-syllable-final phonological positions. Looking at the probabilities of each /r/ variant across phonological positions in both word classes, it is clear that for the labiodental approximant variants - Scores 1 and 2 (i.e. weak labiodental approximant, strong labiodental approximant), the general effects of phonological positions are not affected by word class (see Table 4.14). For example, strong labiodental approximants (i.e. Score 2) are most likely to occur in syllable-initial positions (content word – 20.1%, function word – 10%) and least likely to occur intervocalically (content word – 8%, function word – 2.8%) across both word classes. Further evidence is seen in Table 4.16 where for function words, the log odds of strong labiodental approximant (i.e. Score 2) versus strong post-alveolar approximant (i.e. Score 4) occurrences in intervocalic position (log odds of -3.89, $p < .001$) increases by 2.24 ($p < .001$) and 1.89 ($p < .001$) when in syllable-initial and syllable-initial consonant cluster positions respectively instead. The log odds of strong labiodental approximant (i.e. Score 2) versus strong post-alveolar approximant (i.e. Score 4) occurrences in syllable-initial consonant clusters also increases, by 0.28 despite its non-significance, if in syllable-initial position. A similar finding is seen for content words. The log odds of strong labiodental approximant (i.e. Score 2) versus strong post-alveolar approximant (i.e. Score 4) occurrences in intervocalic position (log odds of -3.98, $p < .001$) increases by 2.54 ($p < .001$) and 1.38 ($p < .001$) when in syllable-initial and syllable-initial consonant cluster positions respectively. And, the log odds of strong labiodental approximant (i.e. Score 2) versus strong post-alveolar approximant (i.e. Score 4) occurrences in syllable-initial consonant clusters (log odds of -2.50, $p < .001$) also increases, by 1.16 ($p < .001$) if in syllable-initial position. While the direction of phonological position effect is the same, what can be observed here is the difference in extent of phonological position effect between word classes – the difference in probabilities of strong labiodental approximant (i.e. Score 2) occurrence in syllable-initial consonant clusters and in syllable-initial positions is larger in content words than in function words.

Patterns of predicted probabilities for null realisations (i.e. Score 0), weak and strong post-alveolar approximants (i.e. Scores 3 and 4), and taps/trills (i.e. Score 5), however, appear to have word class effects. For null realisations (i.e. Score 0) and taps/trills (i.e. Score 5), effects can be seen in function words where the former is more likely to occur intervocalically (e.g. *very*) than in syllable-initial consonant clusters (e.g. *from*) and the latter has a completely reverse pattern of phonological position effects when compared to their occurrences in content words (see Table 4.14). Contrastingly, while there are no differences in phonological position effects for weak and strong post-alveolar approximants (i.e. Scores 3 and 4) in function words, differences in the probabilities of these variants across phonological positions are seen in content words (see Table 4.14). Weak post-alveolar approximants (i.e. Score 3) in function words have the highest predicted probabilities in syllable-initial consonant clusters (e.g. *through*) (23.5%), followed by intervocalic positions (e.g. *very*) (9.7%) and the lowest in syllable-initial positions (e.g. *already*) (1.2%). This is supported by factor significance presented in Table 4.16. The log odds of weak post-alveolar approximant (i.e. Score 3) versus strong post-alveolar approximant (i.e. Score 4) occurrences in both intervocalic (log odds of -1.62, p < .001) and syllable-initial consonant cluster (log odds of -0.66, *n.s.*) positions decrease by 2.12 (p < .01) and 2.96 (p < .001) respectively if in syllable-initial position instead. Additionally, in intervocalic position, the log odds of weak post-alveolar approximant (i.e. Score 3) versus strong post-alveolar approximant (i.e. Score 4) occurrences (log odds of -1.62, p < .001) indeed increases, by 0.95 (p < .05), if in syllable-initial consonant clusters. For content words, this pattern differs slightly. Weak post-alveolar approximants (i.e. Score 3) are still most likely to occur in syllable-initial consonant clusters (22.9%) when in content words (e.g. *cruise*). This is also evident in the MLR analysis where the log odds of weak post-alveolar approximant (i.e. Score 3) versus strong post-alveolar approximant (i.e. Score 4) occurrences in syllable-initial consonant cluster position (log odds of -1.04, p < .001) decreases by 1.43 (p < .001) if in syllable-initial position and that in intervocalic position (log odds of -3.34, p < .001) increases by 2.24 (p < .001) if in syllable-initial consonant clusters instead. However, for content words, there is a higher predicted probability of weak post-alveolar approximant (i.e. Score 3) occurrences in syllable-initial position (e.g. *room*) (4.1%) than intervocalically (e.g. *camera*) (2.5%) although this difference is arguably small – the log odds of weak post-alveolar approximant (i.e. Score 3) versus strong post-alveolar approximant (i.e. Score 4) occurrences in intervocalic position (log odds of -3.34, p < .001) increases by 0.68 (*n.s.*) if in syllable-initial position.

Table 4.16: Coefficients, significance and standard errors (in parentheses), generated from the MLR model, of /r/ variants (Scores 2 and 3) for non-syllable-final phonological positions in combined speech styles; reference level (/r/ score): Score 4.

Function word

Phonological position		**/r/ score**	
reference level	**focus level**	**3**	**2**
(Intercept)		-1.62^{***} (0.47)	-3.89^{***} (0.49)
intervocalic	syllable-initial	-2.12^{**} (0.78)	2.24^{***} (0.40)
(Intercept)		-0.66 (0.37)	-2.30^{***} (0.42)
syllable-initial consonant cluster	syllable-initial	-2.96^{***} (0.66)	0.28 (0.32)
(Intercept)		-1.62^{***} (0.47)	-3.89^{***} (0.49)
intervocalic	syllable-initial consonant cluster	0.95^{*} (0.39)	1.89^{***} (0.36)

Content word

Phonological position		**/r/ score**	
reference level	**focus level**	**3**	**2**
(Intercept)		-3.34^{***} (0.46)	-3.98^{***} (0.36)
intervocalic	syllable-initial	0.68 (0.50)	2.54^{***} (0.31)

(Intercept)		-1.04^{***} (0.32)	-2.50^{***} (0.30)
syllable-initial consonant cluster	syllable-initial	-1.43^{***} (0.35)	1.16^{***} (0.23)
(Intercept)		-3.34^{***} (0.46)	-3.98^{***} (0.36)
intervocalic	syllable-initial consonant cluster	2.24^{***} (0.40)	1.38^{***} (0.31)

Significance codes: ‘***’ $p < 0.001$, ‘**’ $p < 0.01$, ‘*’ $p < 0.05$

For strong post-alveolar approximants (i.e. Score 4), word class effects are seen in a change in the phonological position which most likely promotes its occurrence. While strong post-alveolar approximants (i.e. Score 4) are most likely to occur in syllable-initial position when in function words (e.g. *rather*) (77.5%), they have the highest predicted probability of occurrence in intervocalic position when in content words (e.g. *arrived*) (80.5%). Nonetheless, it remains certain that syllable-initial consonant clusters are the least likely to condition a strong post-alveolar approximant (i.e Score 4) realisation for both word classes (e.g. *across*, *green*) (see Table 4.14).

Based on the above analysis, the following word class effects can be determined:

- /r/ realisation in SgE is affected by word class effects in various ways.
- Taps/trills (i.e. Score 5) are more likely to occur in function words than in content words regardless of which phonological position /r/ is in.
- Null realisations (i.e. Score 0), weak labiodental approximants (i.e. Score 1), and weak post-alveolar approximants (i.e. Score 3) are also generally more likely to occur in function words than in content words regardless of which phonological position /r/ is in. An exception is when /r/ is realised in syllable-initial position - weak labiodental approximants (i.e. Score 1) are more likely to occur in content words than in function words. However, the difference is small.
- On the whole, null realisations (i.e. Score 0), weak labiodental approximants (i.e. Score 1), weak post-alveolar approximants (i.e. Score 3), and taps/trills (i.e. Score 5)

are most likely to occur when /r/ is in syllable-initial consonant clusters of function words (e.g. *from*).

- Strong labiodental approximants (i.e. Score 2) and strong post-alveolar approximants (i.e. Score 4) are generally more likely to occur in content words than in function words regardless of which phonological position /r/ is in. An exception is when /r/ is realised in syllable-initial position – strong post-alveolar approximants (i.e. Score 4) are more likely to occur in function words than in content words.
- When including word class as a contributing factor, strong post-alveolar approximants (i.e. Score 4) are found most likely to occur intervocalically in content words and not in syllable-initial position.
- Strong labiodental approximants (i.e. Score 2) are most likely to occur when /r/ is in syllable-initial position of content words (e.g. *rail*)

Through this analysis of word class effects, it can be seen that for some variants of /r/ there is interaction between phonological position and word class. However, what is most outstanding is that in addition to syllable-initial consonant clusters, occurrence in function words (e.g. *from*) also contributes to a higher likelihood of perceptually weaker /r/ realisations, specifically within the variants of approximant /r/ (i.e. Score 1 vs. Score 2, Score 3 vs. Score 4).

4.4.3 Following context

From the results reported in Sections 4.4.1 and 4.4.2, it is clear that the linguistic factors of phonological position and word class affect each /r/ variant in different ways. However, a pattern of /r/ weakening promoted by language internal factors seems to be emerging. To complete the analysis of effects of linguistic factors, the last linguistic factor to be included was that of following context. Illustrated in Figure 4.20 are the predicted probabilities of each /r/ variant in the three non-syllable-final phonological positions plotted against the six following vowel contexts (delineation of the corresponding vowels in SgE can be found in Section 3.2). These were obtained from the same MLR model as reported in Section 4.4.1 and are also presented in Table 4.17.

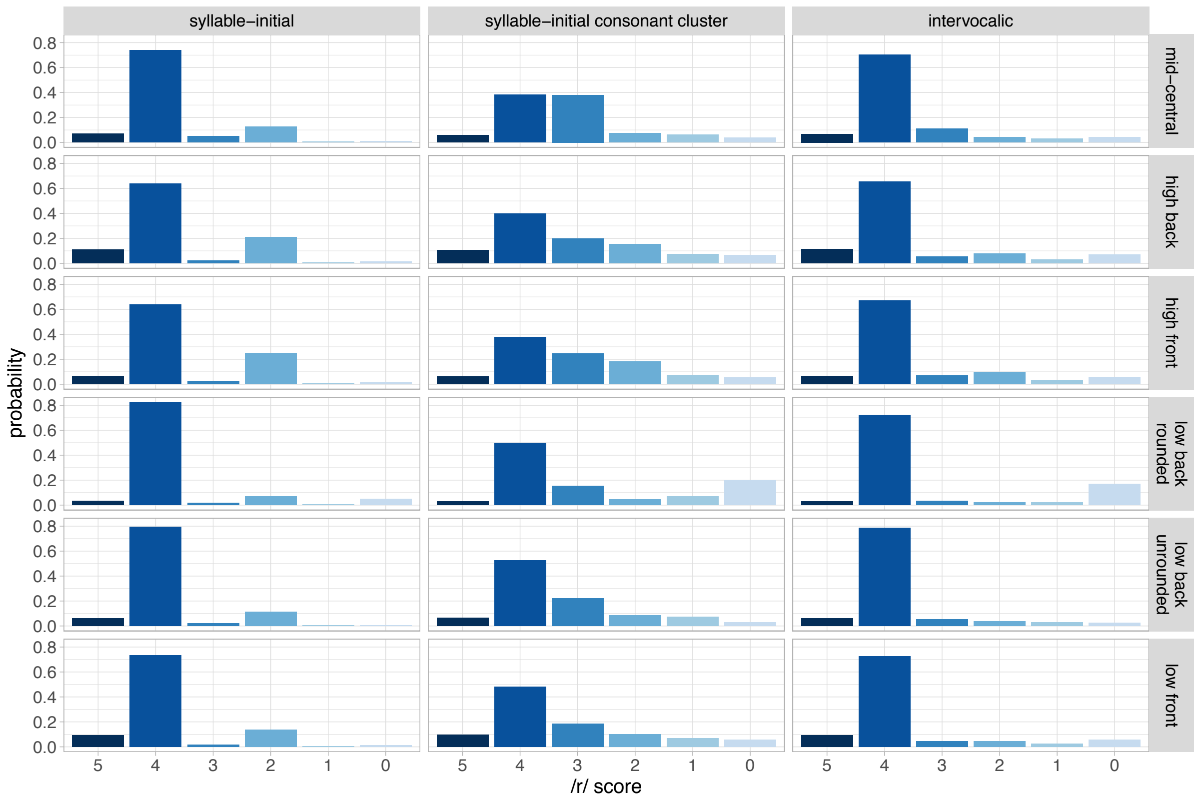

Figure 4.20: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in combined speech styles, according to non-syllable-final phonological position (presented in three columns, left to right – syllable-initial, syllable-initial consonant cluster, intervocalic), and following context (presented in six rows; top to bottom – mid-central, high back, high front, low back rounded, low back unrounded, low front), (n = 17,886).

Table 4.17: Average predicted probabilities (rounded off to 3 decimal places), generated from the MLR model, of /r/ variants for each non-syllable-final phonological position and following context in combined speech styles.

Phonological position	**Following context**	**/r/ score**					
		5	**4**	**3**	**2**	**1**	**0**
syllable-initial	mid-central	0.069	0.739	0.050	0.127	0.005	0.011
	high back	0.110	0.640	0.021	0.209	0.005	0.015
	high front	0.065	0.640	0.027	0.251	0.005	0.013
	low back rounded	0.032	0.824	0.018	0.070	0.005	0.051
	low back unrounded	0.062	0.793	0.022	0.112	0.004	0.006
	low front	0.094	0.733	0.019	0.137	0.004	0.013

syllable-initial consonant cluster	mid-central	0.059	0.383	0.381	0.076	0.064	0.038
	high back	0.107	0.397	0.199	0.154	0.075	0.067
	high front	0.060	0.379	0.248	0.184	0.076	0.053
	low back rounded	0.032	0.498	0.154	0.046	0.071	0.199
	low back unrounded	0.065	0.525	0.222	0.085	0.073	0.029
	low front	0.096	0.481	0.187	0.103	0.072	0.060
intervocalic	mid-central	0.069	0.705	0.110	0.043	0.030	0.043
	high back	0.113	0.656	0.053	0.077	0.031	0.071
	high front	0.067	0.672	0.070	0.097	0.034	0.059
	low back rounded	0.031	0.722	0.032	0.021	0.024	0.170
	low back unrounded	0.063	0.788	0.054	0.039	0.028	0.028
	low front	0.095	0.727	0.045	0.047	0.027	0.058

Analysing both across and within phonological positions in combined speech styles, observations of following context effects on null realisations (i.e. Score 0), strong labiodental approximants (i.e. Score 2), weak post-alveolar approximants (i.e. Score 3) and taps/trills (i.e. Score 5) can be made. In all three non-syllable-final phonological positions, the following context of a low back rounded vowel (e.g. *problem*) appears to have the highest predicted probability of promoting a null realisation (i.e. Score 0). Conversely, it has the lowest predicted probability of promoting a tap/trill (i.e. Score 5). These are further supported by the results of the MLR analysis as presented in Table 4.18. The positive coefficients and factor significance for Score 0 with low back rounded following context (focus level) in all three non-syllable-final phonological positions indicate that the log odds of an occurrence of a null realisation (i.e. Score 0) versus a strong post-alveolar approximant (i.e. Score 4) always increases when the following context is a low back rounded vowel instead of a mid-central vowel ($p < .001$). At the same time, the log odds of an occurrence of a null realisation (i.e. Score 0) versus a strong post-alveolar approximant (i.e. Score 4) either increases only by a small extent (*n.s.*) or decreases when moving from a mid-central vowel following context to all other following contexts. The negative coefficients for Score 5 with low back rounded following context (focus level) in all non-syllable-final phonological positions, on the other hand, indicate that the log odds of an occurrence of a tap/trill (i.e. Score 5) versus a strong post-alveolar approximant (i.e. Score 4) consistently decreases when moving from the following context of a mid-central vowel to a low back unrounded vowel. This is further substantiated by the fact that the log odds of an occurrence of a tap/trill (i.e. Score 5) versus a strong post-alveolar approximant (i.e. Score 4) will either decrease only by a small extent (*n.s.*) or increase when moving from a mid-central vowel following context to all other following contexts. Following contexts of high back (e.g. *road*, *group*, *Europe*) and low front (e.g. *refugee*, *brands*, *correct*) vowels, however, appear to promote the realisation of taps/trills (i.e. Score 5), again, across all non-syllable-final phonological positions as seen in Figure 4.20. In all three phonological positions, the log odds of an occurrence of a tap/trill (i.e. Score 5) versus a strong post-alveolar approximant (i.e. Score 4) increases when moving from the following context of a mid-central vowel to a high back vowel ($p < .01$). When in syllable-initial and intervocalic positions, the log odds of a tap/trill (i.e. Score 5) versus a strong post-alveolar approximant (i.e. Score 4) occurrence also increases when moving from the following context of a mid-central vowel to a low front vowel ($p < .05$). The log odds decrease, albeit insignificantly, when moving to all other following contexts.

Table 4.18: Coefficients, significance and standard errors (in parentheses), generated from the MLR model, of /r/ variants for following context in combined speech style, according to non-syllable-final phonological position; reference level (/r/ score): Score 4.

Syllable-initial						
Following context		**/r/ score**				
reference level	**focus level**	**5**	**3**	**2**	**1**	**0**
(Intercept)		-6.39^{***} (1.24)	-2.48^{***} (0.43)	-1.39^{***} (0.31)	-2.70^{***} (0.60)	-8.03^{***} (1.27)
mid-central	high back	0.73^{**} (0.27)	-0.72^{***} (0.13)	0.74^{***} (0.14)	0.42 (0.29)	0.42 (0.36)
mid-central	high front	-0.17 (0.22)	-0.49^{***} (0.08)	0.97^{***} (0.11)	0.48^{*} (0.23)	0.20 (0.29)
mid-central	low back rounded	-1.66^{***} (0.40)	-1.16^{***} (0.12)	-0.77^{***} (0.17)	0.05 (0.26)	1.51^{***} (0.30)
mid-central	low back unrounded	-0.26 (0.25)	-0.91^{***} (0.09)	-0.17 (0.12)	-0.00 (0.25)	-1.37^{***} (0.41)

mid-central	low front	0.48* (0.24)	-1.03*** (0.10)	0.06 (0.12)	0.17 (0.25)	0.07 (0.35)

Syllable-initial consonant cluster

Following context		/r/ score				
reference level	**focus level**	**5**	**3**	**2**	**1**	**0**
(Intercept)		-5.37*** (0.93)	-1.04*** (0.32)	-2.50*** (0.30)	-5.89*** (0.75)	-4.33*** (0.74)
mid-central	high back	0.73** (0.25)	-0.62*** (0.13)	0.66*** (0.14)	0.11 (0.26)	0.51 (0.31)
mid-central	high front	-0.01 (0.20)	-0.40*** (0.08)	0.94*** (0.11)	0.25 (0.20)	0.28 (0.26)
mid-central	low back rounded	-1.01** (0.33)	-1.18*** (0.12)	-0.77*** (0.17)	-0.14 (0.23)	1.42*** (0.27)
mid-central	low back unrounded	-0.20 (0.23)	-0.88*** (0.09)	-0.18 (0.12)	-0.21 (0.21)	-0.68* (0.32)
mid-central	low front	0.43 (0.22)	-0.96*** (0.10)	0.05 (0.12)	-0.20 (0.22)	0.14 (0.30)

Intervocalic

Following context		/r/ score				
reference level	**focus level**	**5**	**3**	**2**	**1**	**0**
(Intercept)		-5.46*** (0.94)	-3.34*** (0.46)	-3.98*** (0.36)	-9.34*** (0.97)	-4.75*** (0.79)
mid-central	high back	0.78** (0.25)	-0.71*** (0.13)	0.69*** (0.14)	0.11 (0.25)	0.56 (0.32)
mid-central	high front	-0.00 (0.20)	-0.42*** (0.08)	0.95*** (0.11)	0.20 (0.19)	0.35 (0.26)
mid-central	low back rounded	-1.05** (0.33)	-1.18*** (0.12)	-0.77*** (0.17)	-0.16 (0.23)	1.52*** (0.27)
mid-central	low back unrounded	-0.20 (0.23)	-0.90*** (0.09)	-0.22 (0.12)	-0.26 (0.21)	-0.64* (0.32)
mid-central	low front	0.45* (0.22)	-0.98*** (0.10)	0.06 (0.12)	-0.18 (0.22)	0.21 (0.31)

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

The effect of following context on weak post-alveolar approximants (i.e. Score 3) is particularly outstanding. The predicted probability of a weak post-alveolar approximant (i.e. score 3) realisation appears to increase when followed by a mid-central vowel. Although applicable across all non-syllable-final phonological positions, this is especially evident in syllable-initial consonant clusters where a following mid-central vowel (e.g. *different*) causes a weak post-alveolar approximant (i.e. Score 3) to be almost as likely to occur as a strong post-alveolar approximant (i.e. Score 4) (see Figure 4.20). This is supported by the fact that, as seen in Table 4.19 for all three non-syllable-final phonological positions, the log odds of producing a weak post-alveolar approximant (i.e. Score 3) versus a strong post-alveolar approximant (i.e. Score 4) decreases when moving from the following context of a mid-central vowel to all other following contexts ($p < .001$). The finding here not only supports the hypothesis of syllable-initial consonant clusters promoting perceptually weaker /r/ realisations but also highlights the role of a following mid-central vowel, suggesting a link between unstressed syllables, which commonly comprise the mid-central vowel, and perceptually weaker /r/ realisations.

A strong labiodental approximant (i.e. Score 2) realisation appears to be most likely when the following context is a high front (e.g. *really*, *pretty*, *carry*) or a high back (e.g. *ruins*, *cruise*, *aeroplane*) vowel (see Figure 4.20 and Table 4.19). The log odds of a strong labiodental approximant (i.e. Score 2) versus a strong post-alveolar approximant (i.e. Score 4) realisation increases when moving from a mid-central vowel following context to both a high front vowel and a high back vowel following contexts ($p < .001$). This is true for all non-syllable-final phonological positions. A following low back rounded vowel appears to have the lowest predicted probability of co-occurring with a strong labiodental approximant (i.e. Score 2), and this is closely followed by the following context of a low back unrounded vowel. Table 4.19 shows that the log odds of producing a strong labiodental approximant (i.e. Score 2) versus a strong post-alveolar approximant (i.e. Score 4) decreases when moving from the following context of a mid-central vowel to a low back rounded vowel for all non-syllable-final phonological positions ($p < .001$). The negative coefficients for Score 2 (i.e. strong post-alveolar approximant) with a following low back unrounded vowel in all phonological positions also support the analysis of predicted probabilities although no factor significance was found. Supporting earlier claims of a complementary relationship between the strong labiodental approximant (i.e. Score 2) and its post-alveolar counterpart (i.e. Score

4), a directly reverse pattern can be seen in the effects of following context on the latter. In all non-syllable-final phonological positions, there are higher predicted probabilities of strong post-alveolar approximant (i.e. Score 4) realisations when followed by low back rounded (e.g. *rock*, *Prof*, *Morocco*) and low back unrounded (e.g. *rather*, *around*, *transportation*) vowels and lower predicted probabilities when followed by high back and high front vowels. The log odds of strong post-alveolar approximant (i.e. Score 4) versus strong labiodental approximant (i.e. Score 2) occurrences is also seen to increase when the following context is a low back rounded vowel ($p < .001$) and to decrease when the following context is either a high back or high front vowel ($p < .001$) instead of a mid-central vowel (see Table 4.19).

Table 4.19: Coefficients, significance and standard errors (in parentheses), generated from the MLR model, of /r/ variants for following context in combined speech styles, according to non-syllable-final phonological position; reference level (/r/ score): Score 2.

Syllable-initial		
Following context		**/r/ score**
reference level	**focus level**	**4**
(Intercept)		1.49*** (0.31)
mid-central	high back	-0.79*** (0.14)
mid-central	high front	-1.01*** (0.11)
mid-central	low back rounded	0.81*** (0.18)
mid-central	low back unrounded	0.15 (0.12)
mid-central	low front	-0.07 (0.12)
Syllable-initial consonant cluster		
following context		**/r/ score**
reference level	**focus level**	**4**
(Intercept)		2.32*** (0.30)
mid-central	high back	-0.71*** (0.14)
mid-central	high front	-1.00*** (0.11)
mid-central	low back rounded	0.79*** (0.17)

mid-central	low back unrounded	0.16 (0.12)
mid-central	low front	-0.10 (0.12)

Intervocalic		
following context		**/r/ score**
reference level	**focus level**	**4**
(Intercept)		3.84^{***} (0.36)
mid-central	high back	-0.68^{***} (0.14)
mid-central	high front	-0.98^{***} (0.11)
mid-central	low back rounded	0.75^{***} (0.17)
mid-central	low back unrounded	0.23 (0.12)
mid-central	low front	-0.08 (0.12)

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

Following contexts are, thus, evidenced to have the following effects on non-syllable-final /r/ realisations in SgE:

- Taps/trills (i.e. Score 5) are more likely to occur when /r/ is followed by high back or low front vowels, regardless of phonological position – in particular, high back vowels in intervocalic position.
- Null realisations (i.e. Score 0) are most likely to occur when /r/ is followed by low back rounded vowels, regardless of phonological position but particularly in syllable-initial consonant clusters.
- Strong labiodental approximants (i.e. Score 2) are more likely to occur when /r/ is followed by high front or high back vowels, regardless of phonological position – in particular, high front vowels in syllable-initial position.
- Strong post-alveolar approximants (i.e. Score 4) are more likely to occur when /r/ is followed by low back vowels, regardless of phonological position – particularly low back rounded vowels in syllable-initial position.
- Weak post-alveolar approximants (i.e. Score 3) are most likely to occur when /r/ is followed by mid-central vowels, regardless of phonological position but particularly

evident in syllable-initial consonant clusters. This further supports the earlier evidence of syllable-initial consonant clusters promoting weaker /r/ realisations and is rather intuitive given the links between mid-central vowels, weaker /r/ realisations and unstressed syllables.

From the results presented so far, it is clear that linguistic factors do have effects on non-syllable-final /r/ realisations in SgE, albeit in varying ways and degrees. Besides effects of linguistic factors, those of non-linguistic factors were also analysed using the same statistical models and are reported in the next sections.

4.4.4 Speech style

An outstanding non-linguistic factor which was found to have significant effects on /r/ realisation in SgE is speech style (see Table 4.7). Statistical analyses were done on read and conversational speech data separately to make the analysis computationally easier as including both into the same model multiplied the number of reference levels exponentially, causing challenges in interpretation. Following the analysis conducted on combined speech data, both an MLR and an LME model were fitted for non-syllable-final /r/ on read speech only and then separately on conversational speech only. Both the MLR and LME models have simpler fixed effects structures, as shown in Table 4.20, while the LME models have the same random effects structures as earlier models. Results of the analysis of variance of both LME models (i.e. read speech only and conversational speech only), using the *anova* function in the lmerTest package (Kuznetsova et al., 2016) in R (R Core Team, 2016) are shown in Tables 4.21 and 4.22.

Table 4.20: Parameters of both read speech and conversational speech models.

Fixed effects (6)	Interactions (10)	
Age	Age : Speaker sex	Speaker sex : Phonological position
Speaker sex	Age : Ethnicity	Speaker sex : Word class
Ethnicity	Age : Phonological position	Ethnicity : Phonological position
Phonological position	Age : Word class	Ethnicity : Word form
Word class	Gender : Ethnicity	Phonological position : Word form
Following context		

Table 4.21: Analysis of Variance table of the LME model of /r/ variants in non-syllable-final positions in read speech only (values rounded off to 3 decimal places), (n = 10,001).

Parameter	Sum Sq	Mean Sq	Num df	Den df	*F* Value	Pr(>*F*)	Sig.
Age	6.634	6.634	1	105.3	9.541	0.003	**
Ethnicity	2.891	0.964	3	91.8	1.386	0.252	
Speaker sex	0.003	0.003	1	91.5	0.005	0.944	
Phonological position	12.646	6.323	2	222.5	9.093	1.600E-04	***
Word class	0.751	0.751	1	176.8	1.080	0.300	
Following context	9.774	1.955	5	86.9	2.811	0.021	*
Age:Ethnicity	4.611	1.537	3	90.3	2.210	0.092	
Age:Speaker sex	0.190	0.190	1	90.3	0.273	0.602	
Age:Phonological position	4.831	2.416	2	97.4	3.474	0.035	*
Age:Word class	2.610	2.610	1	9603.0	3.753	0.053	
Ethnicity:Speaker sex	5.299	1.766	3	90.3	2.540	0.061	
Ethnicity:Phonological position	15.359	2.560	6	98.3	3.681	0.002	**
Ethnicity:Word class	4.977	1.659	3	9601.0	2.386	0.067	
Speaker sex:Phonological position	9.225	4.612	2	99.3	6.633	0.002	**
Speaker sex:Word class	0.431	0.431	1	9606.9	0.619	0.431	
Phonological position:Word class	2.054	1.027	2	124.3	1.477	0.232	

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

Table 4.22: Analysis of Variance table of the LME model of /r/ variants in non-syllable-final positions in conversational speech only (values rounded off to 3 decimal places), (n = 7885).

Parameter	Sum Sq	Mean Sq	Num df	Den df	F Value	Pr(>F)	Sig.
Age	0.773	0.773	1	49.6	0.916	0.343	
Ethnicity	6.514	2.171	3	47.9	2.573	0.065	
Speaker sex	0.019	0.019	1	46.4	0.022	0.882	
Phonological position	9.644	4.822	2	69.6	5.714	0.005	**
Word class	13.919	13.919	1	5342.7	16.492	4.955E-05	***
Following context	46.751	9.350	5	1680.7	11.079	1.616E-10	***
Age:Ethnicity	8.346	2.782	3	47.6	3.297	0.028	*
Age:Speaker sex	0.136	0.136	1	46.0	0.162	0.690	
Age:Phonological position	4.760	2.380	2	57.4	2.820	0.068	
Age:Word class	4.362	4.362	1	7587.1	5.169	0.023	*
Ethnicity:Speaker sex	3.803	1.268	3	47.2	1.502	0.226	
Ethnicity:Phonological position	9.265	1.544	6	54.9	1.830	0.110	
Ethnicity:Word class	12.188	4.063	3	7684.6	4.814	0.002	**
Speaker sex:Phonological position	6.177	3.089	2	53.3	3.660	0.032	*
Speaker sex:Word class	2.379	2.379	1	7660.0	2.818	0.093	
Phonological position:Word class	7.799	3.899	2	1175.0	4.620	0.010	*

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

The analysis of speech style was subsequently built on from what has been found for phonological position and word class effects. Analysing across phonological position and word class, some effects were found for null realisations (i.e. Score 0). Here, it is seen that the word class effects reported in Section 4.2.2 do not apply to null realisations (i.e. Score 0) in read speech. In reading, null realisations (i.e. Score 0) have the highest predicted probability of occurring in consonant clusters, then intervocalically, and the lowest in syllable-initial positions; the phonological position effect reported in Section 4.2.1. This is the same for occurrences in both content and function words (see Figure 4.21 and Table 4.23). This thus means that the word class effect found previously was caused by null realisations in conversation (see Figure 4.22). It can be seen that, in conversational function words, null realisations (i.e. Score 0) are, indeed, most likely to occur in intervocalic positions (16%), followed by syllable-initial consonant clusters (15.6%) and least likely in syllable-initial positions (8%). This effect, however, is small, as reported in Section 4.2.2 and therefore does not weaken the hypothesis of a syllable-initial consonant cluster promoting perceptually weaker /r/ realisations. No effects of speech style on those of phonological position and word class were found for weak and strong labiodental approximant (i.e. Scores 1 and 2), and also weak and strong post-alveolar approximant (i.e. Scores 3 and 4) realisations. The effects of phonological position and word class on these /r/ variants, as reported in Sections 4.4.1 and 4.4.2, remain unaffected by a difference in speech styles (i.e. reading versus conversation). Different speech styles appear to cause different effects on taps/trills (i.e. Score 5) but no discernable patterns can be observed. This could be a result of a small sample size or an implication of the effects of other non-linguistic factors. Further investigation needs to be done before any conclusions can be made.

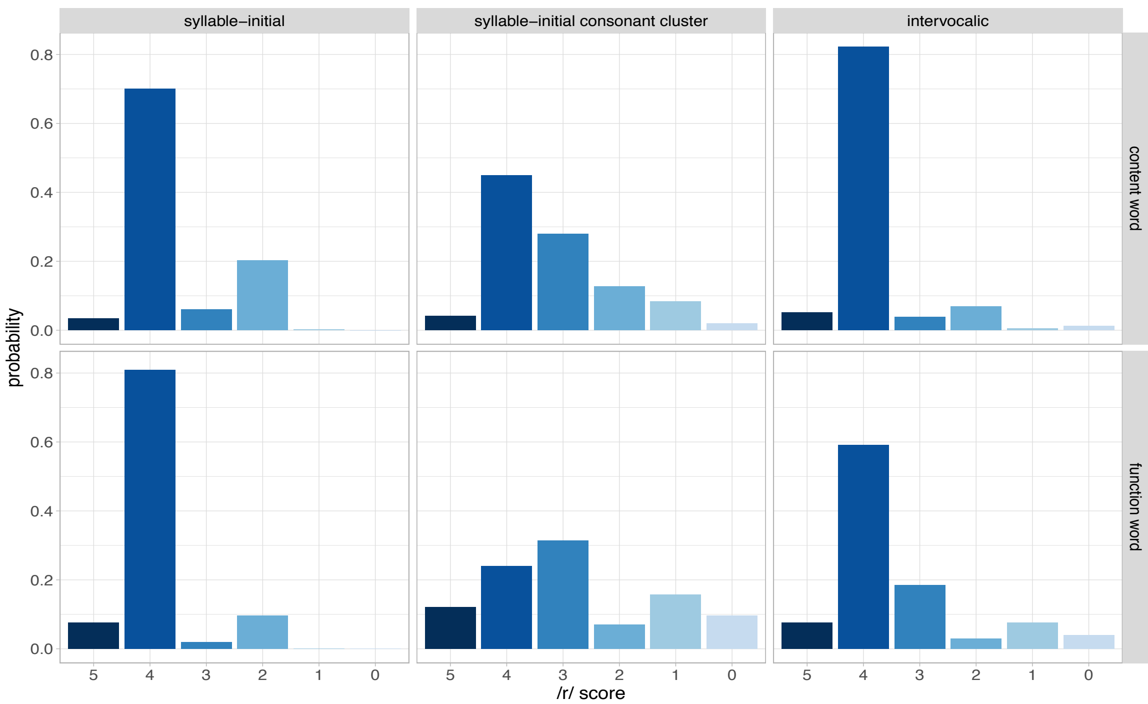

Figure 4.21: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in reading, according to non-syllable-final phonological position (presented in three columns, left to right – syllable-initial, syllable-initial consonant cluster, intervocalic) and word class (presented in two rows; top – content word, bottom – function word), (n = 10,001).

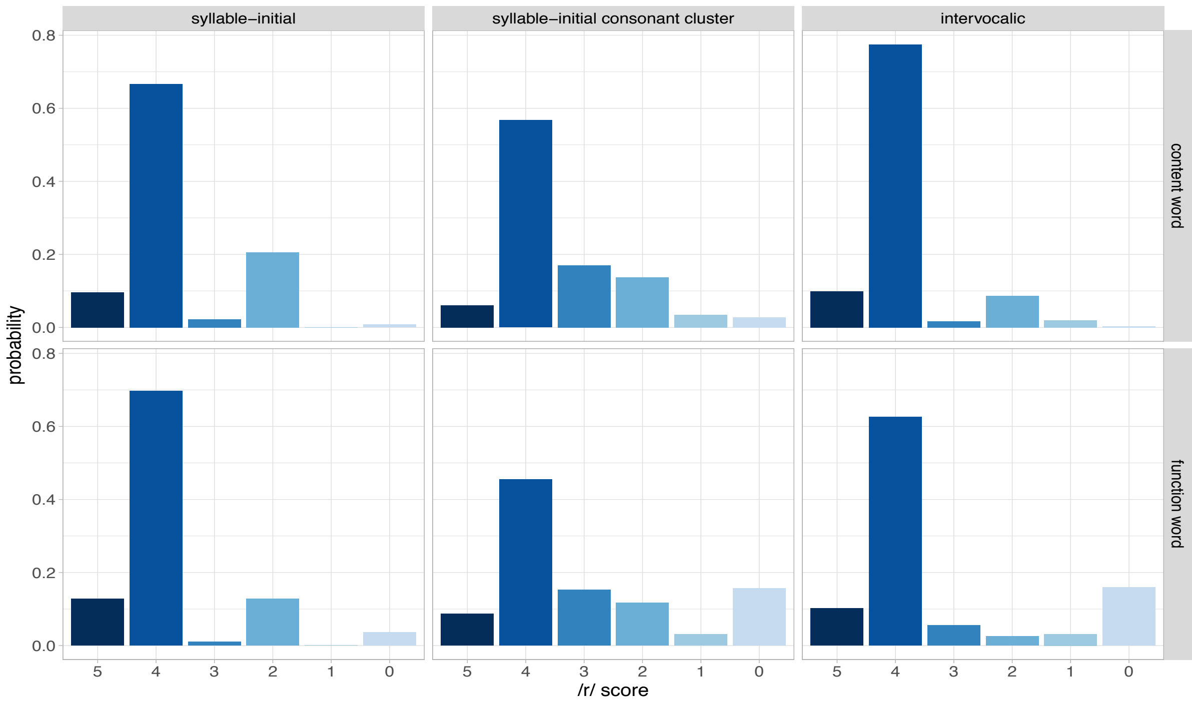

Figure 4.22: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in conversation, according to non-syllable-final phonological position (presented in three columns, left to right – syllable-initial, syllable-initial consonant cluster, intervocalic) and word class (presented in two rows; top – content word, bottom – function word), (n = 7885).

Table 4.23: Average predicted probabilities (rounded off to 3 decimal places), generated from the MLR model, of /r/ variants for each non-syllable-final phonological position and word class in reading and conversation.

Reading							
Phonological position	**Word class**	**/r/ score**					
		5	**4**	**3**	**2**	**1**	**0**
syllable-initial	content	0.034	0.701	0.060	0.202	0.003	2.726e-07
	function	0.076	0.809	0.019	0.096	4.905e-04	2.226e-06
syllable-initial consonant cluster	content	0.041	0.449	0.280	0.127	0.084	0.019
	function	0.121	0.241	0.314	0.071	0.157	0.096
intervocalic	content	0.052	0.822	0.039	0.069	0.006	0.012
	function	0.077	0.592	0.185	0.030	0.077	0.040
Conversation							
Phonological position	**Word class**	**/r/ score**					
		5	**4**	**3**	**2**	**1**	**0**
syllable-initial	content	0.097	0.667	0.022	0.205	0.001	0.008
	function	0.128	0.697	0.010	0.129	0.001	0.036
syllable-initial consonant cluster	content	0.061	0.568	0.171	0.138	0.035	0.028
	function	0.087	0.455	0.152	0.118	0.031	0.156
intervocalic	content	0.099	0.775	0.017	0.087	0.019	0.003
	function	0.102	0.626	0.055	0.025	0.032	0.160

When analysing individual /r/ variants within phonological positions, clearer effects of speech style on /r/ realisation surface, especially in syllable-initial consonant clusters. Within syllable-initial consonant clusters, a null realisation (i.e. Score 0), a strong labiodental approximant (i.e. Score 2), and a strong post-alveolar approximant (i.e. Score 4) are less likely in reading than in conversation (see Table 4.23). Weak labiodental and post-alveolar counterparts (i.e. Scores 1 and 3) in this phonological position, however, are observably higher in reading than in conversation. While this is true of both word classes, function words amplify this trend. Comparing syllable-initial consonant clusters in function words (e.g. *from*) between speech styles (see Figures 4.21 and 4.22), it can be seen that speech style even changes the direction of effect for weak and strong variants of both approximant /r/ realisations (i.e. Score 1 versus Score 2 and Score 3 versus Score 4). Intervocalically (e.g. *very*), the effects of speech style can also be seen. There are lower predicted probabilities of null realisations (i.e. Score 0) and taps/trills (i.e. Score 5), and higher predicted probabilities of weak labiodental approximants (i.e. Score 1) and weak post-alveolar approximants (i.e. Score 3) occurring in reading than in conversation. The extent of speech style can again be seen in a difference in the direction of comparison between two /r/ variants; this time between null realisations (i.e. Score 0) and weak labiodental approximants (i.e. Score 1), as illustrated in Figures 4.21 and 4.22. However, unlike for syllable-initial consonant clusters, speech style appears to have only very slight effects on the predicted probabilities of producing strong labiodental approximants (i.e. Score 2) and strong post-alveolar approximants (i.e. Score 4) in intervocalic position. In syllable-initial positions (e.g. *rather*), there are lower predicted probabilities of null realisations (i.e. Score 0), strong labiodental approximants (i.e. Score 2) and taps/trills (i.e. Score 5), and higher predicted probabilities of weak and strong post-alveolar approximants (i.e. Scores 3 and 4) occurring in reading than in conversation. There is little difference in the predicted probabilities of producing a weak labiodental approximant (i.e. Score 1) between the two speech styles. In this phonological position, the extent of speech style effects is not as outstanding as in the other two positions.

The findings presented so far hint at some levels of interactions amongst the effects of phonological position, word class, and speech style:

- Phonological position alone was found to be of little effect on the occurrence of taps/trills (i.e. Score 5), with syllable-initial consonant clusters to be the least likely position to condition their occurrence. However, this changes once word class and speech style are considered. It can thus be seen that the probability of taps/trills (i.e. Score 5) occurring is more likely based on word class and speech style. They are most likely to occur when /r/ is in syllable-initial consonant clusters of function words in reading and in syllable-initial position of function words in conversational speech, with a higher probability in the latter.
- For null realisations (i.e. Score 0), speech style effects can be seen in conversational speech. As a result, null realisations (i.e. Score 0) are most likely to occur when /r/ is

in intervocalic position and syllable-initial consonant clusters of conversational function words; the higher probability is in the former phonological position.

- Despite speech style effects on weak labiodental approximants (i.e. Score 1) and weak post-alveolar approximants (i.e. Score 3), the effects of phonological position and word class on these weaker variants of approximant /r/ still stand. Both are most likely to occur when /r/ is in syllable-initial consonant clusters of function words in read speech. For both, the next most probable occurrence is when /r/ is in syllable-initial consonant clusters of content words in read speech. This suggests the relative strength of influence phonological position and speech style has on the likelihood of their occurrence.
- Strong labiodental approximants (i.e. Score 2), although affected by speech style, are still most likely to occur when /r/ is in syllable-initial position of content words. This applies to both read and conversational speech, with conversation conditioning a very slightly higher probability of a strong labiodental approximant (i.e. Score 2) occurrence. A general higher occurrence in conversational speech further supports the fact that the strong labiodental approximant (i.e. Score 2) is an emergent variant of /r/ in SgE which occurs more commonly in casual natural speech styles.
- For strong post-alveolar approximants (i.e. Score 4), word class effects presented earlier are found to apply to both read and conversational speech. They are, thus, most likely to occur when there is an intervocalic /r/ in content words within each speech style, with a higher probability of occurrence in read speech. An equal likelihood of occurrence between speech styles is observed for the strong post-alveolar approximant (i.e. Score 4). This was not the initial prediction for this dominant /r/ variant which was expected to occur more often in clear, deliberate, formal speech. However, at this point, there is no evidence of explanations for this. Therefore, the hypothesis is that herein lies the possibility of interactions of various factors at play.

4.4.5 Interactions between linguistic and non-linguistic factors

From the initial LME analysis (see Table 4.24 for results of parameters in question and Table 4.7 for full results), while all linguistic factors are found to be significant, the only non-linguistic factor that has significant effects on /r/ realisation in SgE is speech style. However, most tests of interactions involving non-linguistic factors returned as significant. This reiterates the importance of taking a multidimensional approach in the understanding of /r/ variation in SgE. It is also interesting that there is a difference in the strength of interactional effects amongst the non-linguistic factors; ethnicity and speaker sex appear to have stronger effects on /r/ realisation in SgE than age. However, as mentioned in Section 4.2, there are constraints in analysing age effects further due to the limited data collected from certain age groups - preliminary hypotheses of age effects will be revisited in the discussion and future direction sections of this study (see Chapter Six). Therefore, further analyses of only the implications of ethnicity and speaker sex will be included in this section.

Table 4.24: Excerpt of the Analysis of Variance table of the full LME model of /r/ variants in combined read and conversational speech – only non-linguistic factors and their tested interactions are presented (values rounded off to 3 decimal places), (n = 41,748).

Parameter	**Sum Sq**	**Mean Sq**	**Num df**	**Den df**	***F* Value**	**Pr(>*F*)**	**Sig.**
Age	2.535	2.535	1	94	3.660	0.059	
Ethnicity	5.239	1.746	3	89	2.521	0.063	
Speaker sex	0.211	0.211	1	90	0.305	0.582	
Speech style	20.548	20.548	1	30031	29.663	5.182e-08	***
Age:Ethnicity	7.337	2.446	3	88	3.531	0.018	*
Age:Speaker sex	0.633	0.633	1	89	0.914	0.342	
Age:Speech style	11.786	11.786	1	41422	17.014	3.718e-05	***
Age:Phonological position	4.196	1.399	3	93	2.019	0.117	
Age:Word class	3.733	3.733	1	41281	5.389	0.020	*
Ethnicity:Speaker sex	1.392	0.464	3	86	0.670	0.573	
Ethnicity:Speech style	34.850	11.617	3	40351	16.770	6.966e-11	***
Ethnicity:Phonological position	19.520	2.169	9	89	3.131	0.003	**
Ethnicity:Word class	17.039	5.680	3	41360	8.199	1.881e-05	***
Speaker sex:Speech style	4.762	4.762	1	41035	6.875	0.009	**
Speaker sex:Phonological position	15.721	5.240	3	93	7.565	< 0.001	***
Speaker sex:Word class	12.453	12.453	1	41330	17.977	2.241e-05	***
Speech style:Phonological position	100.712	33.571	3	5454	48.463	< 2.2e-16	***

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

The subsequent analyses of non-linguistic factors and interactions were done by fitting the same MLR models, as reported in Section 4.4.4, on read and conversational speech data separately. For ease of interpretation, the effects of ethnicity and speaker sex on patterns of predicted probabilities of /r/ variants are first plotted and analysed by non-syllable-final phonological positions (see Figures 4.23 and 4.24). An analysis by word class (see Figures 4.25 and 4.26) will follow later in the section.

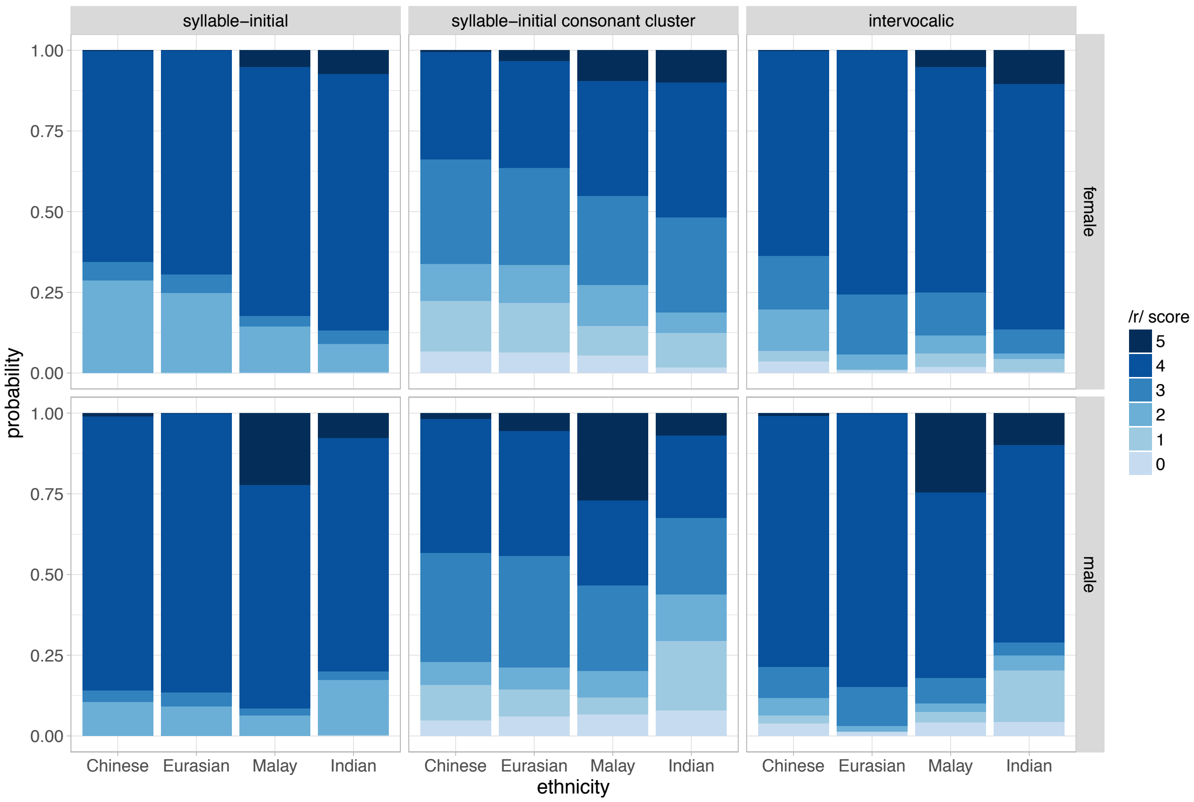

Figure 4.23: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in reading, according to ethnicity, phonological position (presented in three columns, left to right – syllable-initial, syllable-initial consonant cluster, intervocalic), and speaker sex (presented in two rows; top – female, bottom – male), (n = 10,001).

Ethnicity has relatively little effect on phonological position effects when analysing across non-syllable-final phonological positions in read speech. Here, null realisations (i.e. Score 0), weak labiodental approximants (i.e. Score 1) and weak post-alveolar approximants (i.e. Score 3), once again, occur mostly in syllable-initial consonant clusters, less intervocalically, and almost never in syllable-initial positions. This is, additionally, consistent for all ethnicities. Phonological position effects also remain unchanged across all ethnic groups for strong labiodental and strong post-alveolar approximants (i.e. Scores 2 and 4). This consistency amongst ethnic groups further strengthens the hypothesis of syllable-initial consonant clusters promoting perceptually weaker /r/ realisations and provides evidence for it to be a natural language-internal effect that is applicable to the whole community of SgE speakers.

For taps/trills (i.e. Score 5), however, phonological position effects appear to be affected by ethnicity. While all ethnically Malay and Indian SgE speakers realise taps/trills (i.e. Score 5) in all non-syllable-final phonological positions with rather consistent frequency, ethnically Chinese and Eurasian SgE speakers appear to do so mostly in syllable-initial consonant clusters and only very rarely intervocalically and syllable-initially. These observations apply to both male and female SgE speakers (see Table 4.25).

Table 4.25: Average predicted probabilities (rounded off to 3 decimal places), generated from the MLR model, of /r/ variants for each non-syllable-final phonological position, ethnic group, and speaker sex in read speech.

Phonological position	**Ethnicity**	**Speaker sex**	**/r/ score**					
			5	**4**	**3**	**2**	**1**	**0**
syllable-initial	Chinese	female	0.002	0.653	0.059	0.286	0.001	1.149e-06
		male	0.010	0.848	0.036	0.105	8.224e-05	7.648e-07
	Eurasian	female	0.001	0.693	0.057	0.248	0.002	3.305e-07
		male	0.001	0.864	0.042	0.092	2.237e-04	3.840e-07
	Malay	female	0.052	0.771	0.033	0.141	0.003	1.249e-06
		male	0.222	0.692	0.022	0.064	4.092e-04	2.737e-06
	Indian	female	0.073	0.796	0.041	0.086	0.004	2.495e-07
		male	0.077	0.722	0.027	0.170	0.003	3.130e-06
syllable-initial consonant cluster	Chinese	female	0.006	0.332	0.324	0.115	0.156	0.068
		male	0.017	0.416	0.338	0.071	0.109	0.049
	Eurasian	female	0.034	0.330	0.300	0.118	0.152	0.065
		male	0.055	0.388	0.345	0.069	0.084	0.061
	Malay	female	0.095	0.356	0.276	0.126	0.092	0.055
		male	0.270	0.264	0.264	0.084	0.051	0.067
	Indian	female	0.100	0.418	0.294	0.064	0.106	0.018
		male	0.069	0.256	0.236	0.145	0.215	0.078
intervocalic	Chinese	female	0.002	0.634	0.166	0.129	0.031	0.037
		male	0.009	0.777	0.096	0.054	0.026	0.039
	Eurasian	female	0.001	0.755	0.186	0.047	0.002	0.009
		male	0.001	0.847	0.120	0.018	0.001	0.013
	Malay	female	0.052	0.698	0.134	0.056	0.041	0.020
		male	0.246	0.574	0.079	0.027	0.031	0.043
	Indian	female	0.104	0.760	0.075	0.018	0.039	0.004
		male	0.098	0.612	0.040	0.047	0.160	0.043

Generally, female SgE speakers have higher predicted probabilities for lower /r/ scores (i.e. Score 0 – null realisations, Scores 1 and 2 – weak and strong labiodental approximants, Score 3 – weak post-alveolar approximants) while male SgE speakers have higher predicted probabilities for higher /r/ scores (i.e. Score 4 – strong post-alveolar approximants, Score 5 – taps/trills). This is the same across all ethnicities except for ethnically Indian SgE speakers, as clearly illustrated in Figure 4.24. Female ethnically Indian SgE speakers appear to have higher predicted probabilities for higher /r/ scores (i.e. Score 4 – strong post-alveolar approximants, Score 5 – taps/trills) while their male counterparts have higher predicted probabilities for lower /r/ scores (i.e. Score 0 – null realisations, Scores 1 and 2 – weak and strong labiodental approximants, Score 3 – weak post-alveolar approximants). Compared to their counterparts of other ethnicities, female ethnically Indian SgE speakers are always the most likely to produce higher /r/ scores (i.e. Score 4 –strong post-alveolar approximants, Score 5 – taps/trills) and the least likely to produce lower /r/ scores (i.e. Score 0 – null realisations, Scores 1 and 2 – weak and strong labiodental approximants, Score 3 – weak post-alveolar approximants). By contrast, male ethnically Indian SgE speakers are always the least likely to produce higher /r/ scores (i.e. Score 4 –strong post-alveolar approximants, Score 5 – taps/trills) and the most likely to produce lower /r/ scores (i.e. Score 0 – null realisations, Scores 1 and 2 – weak and strong labiodental approximants, Score 3 – weak post-alveolar approximants) as compared to male SgE speakers of the other three ethnicities. While the ethnicity effect on female SgE speakers is an expected finding, that on male SgE speakers is surprising. More investigation on what happens in conversational speech and on the effects of interaction with word class and/or age will be carried out.

In conversational speech, however, more ethnicity effects on phonological position effects when analysing across non-syllable-final phonological positions can be observed, as presented in Figure 4.24. While speech style does not have an effect on the most likely phonological position of strong labiodental approximant (i.e. Score 2) occurrences for SgE speakers from all other ethnic groups (i.e. Chinese, Eurasian, Indian), it does for ethnically Malay SgE speakers. For ethnically Chinese, Eurasian, and Indian SgE speakers, strong labiodental approximants (i.e. Score 2) in conversational speech are still most likely to occur in syllable-initial position (as in read speech) but for ethnically Malay SgE speakers, they are most likely to occur in syllable-initial consonant clusters. For strong post-alveolar approximants (i.e. Score 4), the ethnicity effect is slightly different. While strong post-alveolar approximants (i.e. Score 4) are most likely occur in syllable-initial position in read speech for all SgE speakers, they have the highest probability of occurring intervocalically in conversational speech for only ethnically Eurasian, Malay, and Indian SgE speakers. For this /r/ variant, speech style, again, does not have an effect on ethnically Chinese SgE speakers. However, as in read speech, strong labiodental approximants (i.e. Score 2) remain least likely to occur intervocalically and strong post-alveolar approximants (i.e. Score 4) have the lowest predicted probability of occurring in syllable-initial consonant clusters.

For all ethnic groups, syllable-initial consonant clusters are also again the most likely phonological position in which weak post-alveolar approximants (i.e. Score 3) occur. There is a slightly different situation for null realisations (i.e. Score 0) and weak labiodental approximants (i.e. Score 1) where, for some ethnicity-speaker sex sub-groups (i.e. ethnically Chinese female and male, ethnically Eurasian female, ethnically Indian female), these /r/ realisations could have higher predicted probabilities in intervocalic position than in syllable-initial consonant clusters (see Table 4.26). However, what remains certain is that, for all ethnic groups and in both reading and conversation, these perceptually weaker /r/ realisations are least likely to occur in syllable-initial position. Taken together, these findings of interactional effects, once again, highlight the effect of syllable-initial consonant clusters on perceptually weaker /r/ realisations.

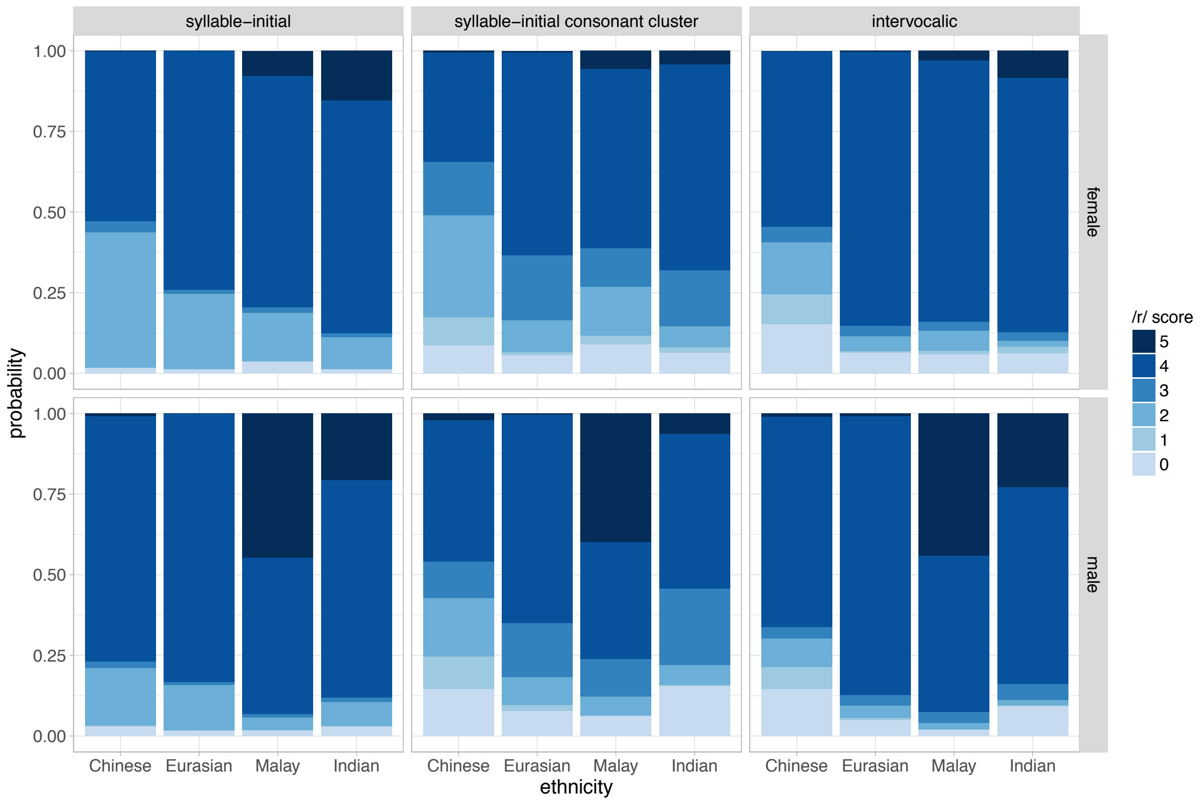

Figure 4.24: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in conversation, according to ethnicity, phonological position (presented in three columns, left to right – syllable-initial, syllable-initial consonant cluster, intervocalic), and speaker sex (presented in two rows; top – female, bottom – male), (*n* = 7885).

Table 4.26: Average predicted probabilities (rounded off to 3 decimal places), generated from the MLR model, of /r/ variants for each non-syllable-final phonological position, ethnic group, and speaker sex in conversational speech.

Phonological position	**Ethnicity**	**Speaker sex**	**/r/ score**					
			5	**4**	**3**	**2**	**1**	**0**
syllable-initial	Chinese	female	0.002	0.526	0.035	0.418	0.001	0.017
		male	0.008	0.761	0.020	0.179	0.002	0.030
	Eurasian	female	0.001	0.739	0.013	0.233	9.512e-05	0.013
		male	0.001	0.833	0.008	0.142	3.357e-04	0.017
	Malay	female	0.077	0.718	0.017	0.150	3.722e-04	0.037
		male	0.448	0.484	0.012	0.039	3.733e-05	0.018
	Indian	female	0.155	0.721	0.011	0.099	0.001	0.012
		male	0.206	0.675	0.013	0.075	0.001	0.030
syllable-initial consonant cluster	Chinese	female	0.006	0.339	0.165	0.317	0.087	0.087
		male	0.021	0.438	0.114	0.181	0.100	0.146
	Eurasian	female	0.004	0.629	0.201	0.100	0.009	0.056
		male	0.004	0.645	0.168	0.086	0.019	0.078
	Malay	female	0.056	0.557	0.118	0.152	0.027	0.090
		male	0.398	0.363	0.117	0.059	0.002	0.062
	Indian	female	0.042	0.639	0.173	0.065	0.017	0.064
		male	0.062	0.481	0.236	0.061	0.004	0.155
intervocalic	Chinese	female	0.001	0.544	0.049	0.160	0.094	0.152
		male	0.010	0.652	0.036	0.088	0.067	0.147
	Eurasian	female	0.004	0.849	0.031	0.048	0.005	0.064
		male	0.008	0.865	0.032	0.039	0.005	0.051
	Malay	female	0.030	0.809	0.029	0.061	0.012	0.059
		male	0.441	0.484	0.035	0.019	3.679e-04	0.021
	Indian	female	0.084	0.788	0.028	0.018	0.019	0.064
		male	0.228	0.611	0.048	0.018	0.002	0.093

Like in reading, ethnicity affects the occurrence of taps/trills (i.e. Score 5) in conversation. In this speech style, however, phonological position effects differed not only across ethnic groups but also, in the case of ethnically Indian SgE speakers, between speaker sex groups. Taps/trills (i.e. Score 5) are most likely to occur in syllable-initial position for female and male ethnically Malay, and female ethnically Indian SgE speakers while for male ethnically Indian and ethnically Eurasian SgE speakers, taps/trills (i.e. Score 5) have the highest predicted probability in intervocalic position. Ethnically Chinese SgE speakers, both females and males, realise taps/trills (i.e. Score 5) mostly in syllable-initial consonant clusters.

Female SgE speakers are more likely to produce lower /r/ scores (i.e. Score 0 – null realisations, Scores 1 and 2 – weak and strong labiodental approximants, Score 3 – weak post-alveolar approximants) while male SgE speakers have higher predicted probabilities for higher /r/ scores (i.e. Score 4 – strong post-alveolar approximants, Score 5 – taps/trills) in conversation. Comparing Figures 4.23 and 4.24, it is clear that this pattern is in accord with speaker sex effects found in read speech. Also, all ethnic groups, again, have the same speaker sex effect except for ethnically Indian SgE speakers who pattern in the opposite manner between speaker sex groups. The extent of the speaker sex effect on ethnically Indian SgE speakers, however, is a lot smaller in conversation than it is in reading. Nonetheless, this difference in speaker sex effect on ethnically Indian SgE speakers is an unexpected and curious finding. Additionally, female ethnically Indian SgE speakers are similarly found to always be the most likely to produce higher /r/ scores (i.e. Score 4 – strong post-alveolar approximants, Score 5 – taps/trills) and the least likely to produce lower /r/ scores (i.e. Score 0 – null realisations, Scores 1 and 2 – weak and strong labiodental approximants, Score 3 – weak post-alveolar approximants) in comparison to other female SgE speakers, as they are in reading. On the contrary, what can be observed for male ethnically Indian SgE speakers in reading is not the case in conversation. In conversation, male ethnically Chinese SgE speakers are the ones found to be the most likely to produce lower /r/ scores (i.e. Score 0 – null realisations, Scores 1 and 2 – weak and strong labiodental approximants, Score 3 – weak post-alveolar approximants) instead. These observations are illustrated in the comparison of Figures 4.23 and 4.24.

When speaker sex and ethnicity effects are analysed with a combined consideration of speech style and word class, no effects are found in the occurrence of the strong approximant

/r/ realisations (i.e. Score 2 – strong labiodental approximant and Score 4 – strong post-alveolar approximant). Both female and male SgE speakers of all ethnicities have higher predicted probabilities of both of these strong approximant /r/ realisations occurring in content words than in function words in both speech styles (i.e. reading and conversation). There are also no effects of speaker sex and ethnicity on word class in both speech styles for the occurrence of null realisations (i.e. Score 0); null realisations (i.e. Score 0) are consistently more likely to occur in function words than in content words in both reading and conversation for all speakers. These findings are presented in Table 4.27 and illustrated in Figures 4.25 and 4.26.

Some effects, however, are seen on the occurrences of weak approximant /r/ realisations (i.e. Score 1 – weak labiodental approximant and Score 3 weak post-alveolar approximant) and taps/trills (i.e. Score 5) (see Table 4.27, and Figures 4.25 and 4.26). For weak labiodental approximants (i.e. Score 1), there are no speaker sex and ethnicity effects in read speech; there is always a lower predicted probability of occurrence in content words than in function words regardless of speaker sex and ethnicity. But when producing weak labiodental approximants (i.e. Score 1) in conversation, male ethnically Chinese SgE speakers do so more in content words than in function words. This group of SgE speakers is also the only one for which tap/trill (i.e. Score 5) occurrences differ. Male ethnically Chinese SgE speakers have a higher likelihood of producing taps/trills (i.e. Score 5) in function words than in content words in conversation, like all other SgE speakers, but are more likely to have taps/trills (i.e. Score 5) in content words than in function words in reading, differing from everyone else. For the majority of SgE speakers in both speech styles, weak post-alveolar approximant (i.e. Score 3) realisations have higher predicted probabilities of occurring in function words than content words. Male ethnically Malay SgE speakers in reading, and ethnically Chinese (both females and males) and female ethnically Malay SgE speakers in conversation were exceptions. In these specific situations, there are higher predicted probabilities of weak post-alveolar approximant (i.e. Score 3) realisations occurring in content words than in function words.

Table 4.27: Average predicted probabilities (rounded off to 3 decimal places), generated from the MLR model, of /r/ variants for each word class, ethnic group, and speaker sex in read and conversational speech.

Reading

Word class	Ethnicity	Speaker sex	/r/ score 5	4	3	2	1	0
content	Chinese	female	0.002	0.576	0.144	0.233	0.033	0.012
		male	0.013	0.725	0.126	0.107	0.022	0.007
	Eurasian	female	0.001	0.630	0.131	0.189	0.036	0.012
		male	0.005	0.746	0.132	0.088	0.020	0.009
	Malay	female	0.028	0.663	0.139	0.129	0.028	0.012
		male	0.206	0.563	0.125	0.074	0.016	0.016
	Indian	female	0.028	0.750	0.118	0.075	0.026	0.002
		male	0.054	0.607	0.096	0.168	0.064	0.012
function	Chinese	female	0.005	0.503	0.221	0.120	0.092	0.058
		male	0.011	0.637	0.187	0.046	0.067	0.051
	Eurasian	female	0.022	0.556	0.231	0.086	0.067	0.037
		male	0.033	0.653	0.206	0.032	0.036	0.040
	Malay	female	0.105	0.554	0.156	0.086	0.063	0.037
		male	0.286	0.457	0.118	0.043	0.039	0.057
	Indian	female	0.156	0.565	0.155	0.037	0.073	0.013
		male	0.109	0.453	0.107	0.074	0.188	0.068

Conversation

Word class	Ethnicity	Speaker sex	/r/ score 5	4	3	2	1	0
content	Chinese	female	0.002	0.484	0.086	0.358	0.059	0.011
		male	0.009	0.659	0.058	0.182	0.072	0.020
	Eurasian	female	0.003	0.751	0.079	0.158	0.003	0.007
		male	0.004	0.805	0.064	0.109	0.007	0.011

	Malay	female	0.044	0.718	0.056	0.159	0.005	0.017
		male	0.417	0.467	0.054	0.050	4.217E-04	0.012
	Indian	female	0.067	0.789	0.067	0.071	4.014E-04	0.006
		male	0.139	0.684	0.098	0.060	1.031E-04	0.020
function	Chinese	female	0.004	0.455	0.080	0.238	0.063	0.160
		male	0.017	0.575	0.055	0.117	0.041	0.195
	Eurasian	female	0.004	0.727	0.085	0.096	0.007	0.082
		male	0.005	0.757	0.075	0.069	0.009	0.086
	Malay	female	0.065	0.671	0.053	0.082	0.021	0.107
		male	0.440	0.420	0.055	0.028	0.001	0.056
	Indian	female	0.120	0.644	0.074	0.051	0.025	0.087
		male	0.192	0.494	0.101	0.043	0.004	0.166

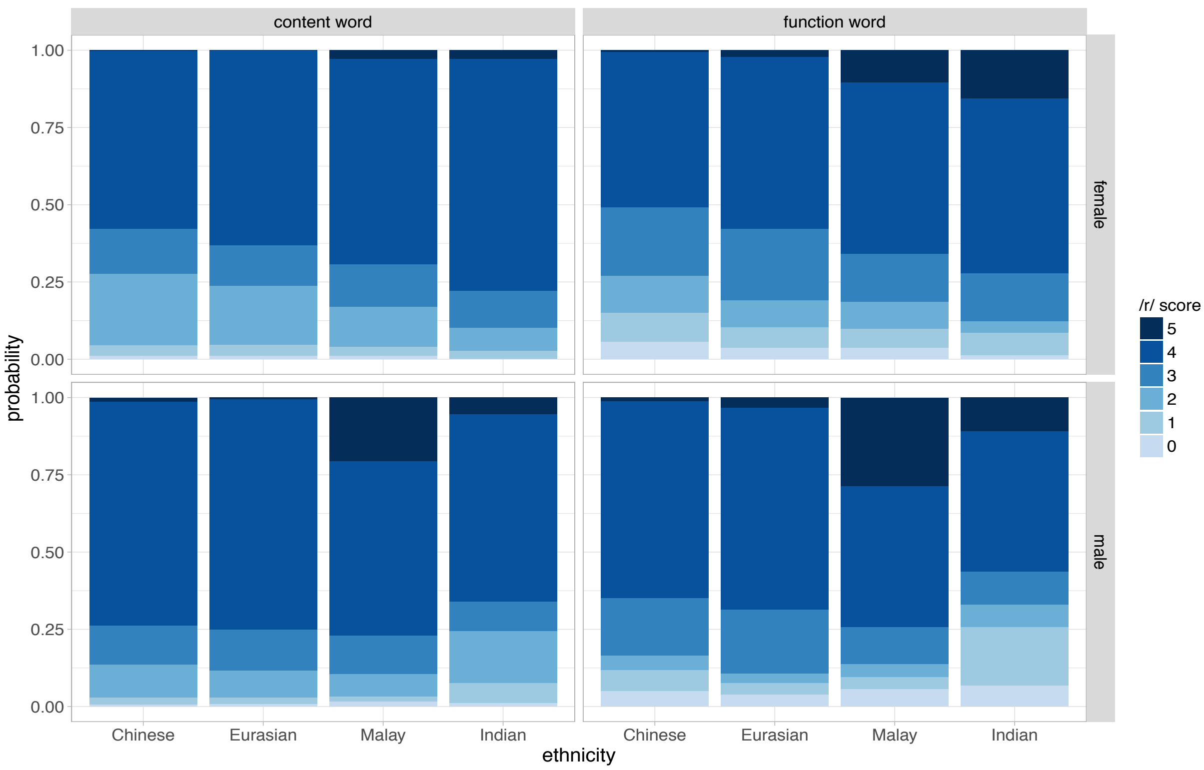

Figure 4.25: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in reading, according to ethnicity, word class (presented in two columns, left – content word, right – function word), and speaker sex (presented in two rows; top – female, bottom – male), (*n* = 10,001).

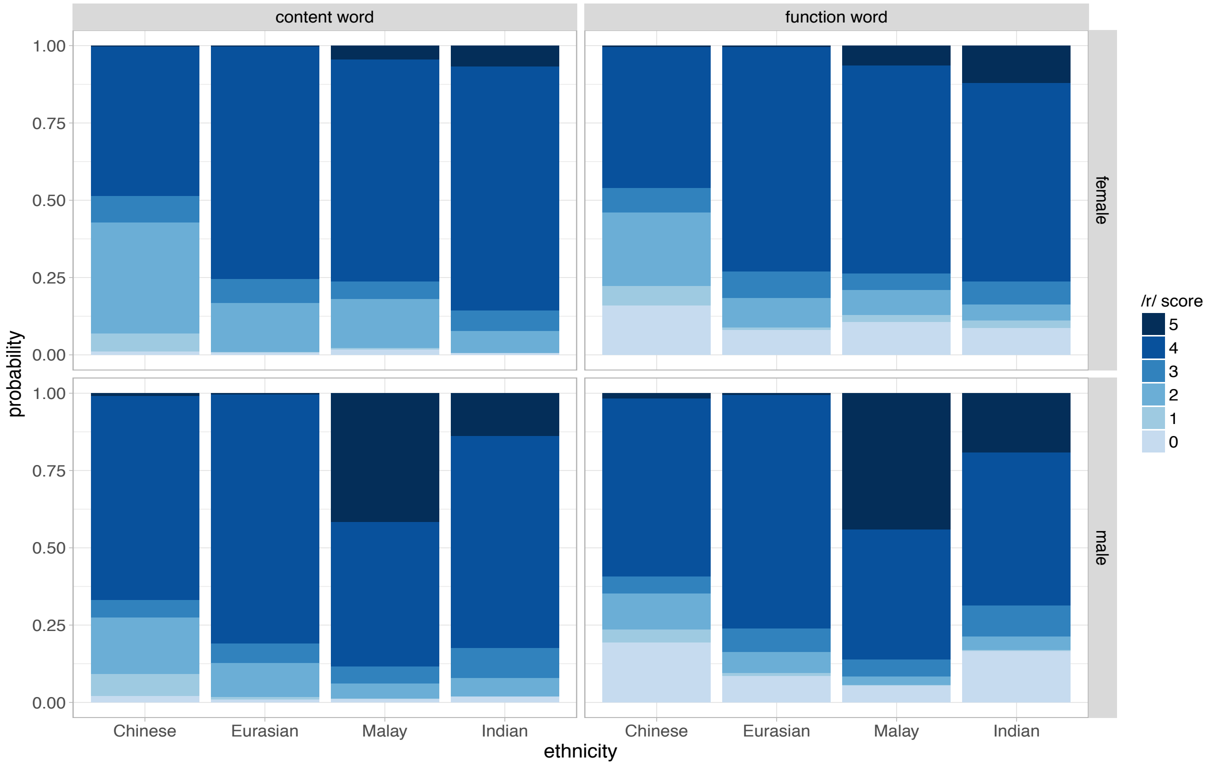

Figure 4.26: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in conversation, according to ethnicity, word class (presented in two columns, left – content word, right – function word), and speaker sex (presented in two rows; top – female, bottom – male), (*n* = 7885).

It appears then that the following effects of interactions between linguistic and non-linguistic factors will contribute to our understanding of /r/ variation in SgE:

- There is an observable effect of interaction between ethnicity, speaker sex, speech style, and phonological position especially on the occurrence of taps/trills (i.e. Score 5).
- For ethnically Chinese SgE speakers, both females and males, taps/trills (i.e. Score 5) are most likely to occur when /r/ is in syllable-initial consonant clusters regardless of speech style. While this is also true for both female and male ethnically Eurasian SgE speakers, and phonological position does not have much effect on tap/trill (i.e. Score 5) occurrences for ethnically Indian and Malay SgE speakers in reading, there is a lot more variation in conversational speech. In conversations, taps/trills (i.e. Score 5) are more likely to occur, for ethnically Malay and female ethnically Indian SgE speakers, when there is a syllable-initial /r/ and, for ethnically Eurasian and male ethnically Indian SgE speakers, when there is an intervocalic /r/.

- Function words also promote the occurrence of taps/trills (i.e. Score 5) for everyone regardless of speech style, with the exception of male ethnically Chinese speakers. For them, taps/trills (i.e. Score 5) are more likely to occur in content words when /r/ is in read speech.
- There is generally less variation in phonological position effects between ethnic groups in read speech than in conversational speech for most /r/ variants, with stability seen only in weak post-alveolar approximants (i.e. Score 3).
- In both speech styles, it is generally more likely for female SgE speakers to produce more perceptually weak /r/ variants (i.e. Scores 0, 1, 2, 3) while it is more likely for male SgE speakers to produce more perceptually strong /r/ variants (i.e. Scores 4, 5), with the exception of ethnically Indian SgE speakers.
- For ethnically Indian SgE speakers, females produce more perceptually strong /r/ variants (i.e. Scores 4, 5) while males produce more perceptually weak /r/ variants (i.e. Scores 0, 1, 2, 3). This is true in both speech styles although the extent of differences is more distinct in reading.

4.4.6 Considerations and summary of findings

All the findings, obtained from the analyses of the MLR models, presented thus far need to be considered alongside results generated from the LME models. This is due to the limitations of the MLR models in accounting for individual speaker differences. From the comparison between an LME random slope model, which includes random effects, and an LM model, which does not include random effects, it can be seen that while there are wider confidence intervals (i.e. longer bottom bars; yellow bars) in the LME model for phonological positions, implying some level of individual speaker effects (see sections in Figure 4.27 marked by blue arrows) and, therefore, caution needs to be taken when reporting the significance of the extent of phonological position effects, there are no changes in the direction of the effects; the coefficients are negative for both LME and LM models. It is thus safe to assume the generalisability of phonological position effects on /r/ realisation in SgE as obtained from the MLR model. As done for phonological position, the effects of individual speaker variation were also analysed for word class. It can be seen that the coefficients and confidence intervals do not differ much between a model which accounts for individual speaker differences (i.e. LME random slope model; yellow bars) and another which does not (i.e. LM model; purple bars) (see section in Figure 4.27 marked by a green arrow). It is thus likely that word class effects from the MLR model as reported in this section are valid and have not masked the effects of individual speaker differences.

Care should also be taken to not inflate the effects of speech style as the LME analysis (see section in Figure 4.27 marked by a red arrow) shows a relatively lower upper limit which is close to 0 for speech style in the LME random slope model 1 (i.e. yellow bar). This implies some level of individual speaker effects on the direction of the effects; there is a lower chance of the coefficient to be positive for the LME random slope model (with random structure) than for the LM model (without random structure). Thus, analyses of individual speaker variation should be conducted to enable a deeper discussion on the effects of speech style.

In analysing the rest of the non-linguistic effects, the degree of individual speaker effects has to be considered as well. From Figure 4.27, it is seen that while most of the relevant parameters do not appear to be much of a concern, there are a few that suggest that some consideration needs to be given to between-speaker differences. Of these parameters, Ethnicity(Eurasian), Ethnicity(Eurasian):Speaker sex(male), and Speaker sex(male):Phonological position(syllable-initial consonant cluster) are the three most important ones to note (see sections in Figure 4.27 marked by grey arrows). They have wider confidence intervals which spread across the zero mark, indicating the possibility of effects occurring in the opposite direction, in the LME random slope model (i.e. yellow bars) than in the LM model (i.e. purple bars). A few others, Speaker sex(male), Ethnicity(Malay), Ethnicity(Malay):Speaker sex(Male), Ethnicity(Indian), and Ethnicity(Indian):Speaker sex(male) (see sections marked by pink arrows), also have observably wider confidence intervals in the LME random slope model (i.e. yellow bars) than in the LM model (i.e. purple bars) and although the direction of effects do not change for these parameters, the more conservative analysis would be to bear in mind the possibility of individual speaker effects. Together, these indicate that in the discussion of non-linguistic factors, their interactions with linguistic factors and the roles these play in /r/ realisation in SgE, care needs to be taken not to overgeneralise observations without alluding to individual speaker differences.

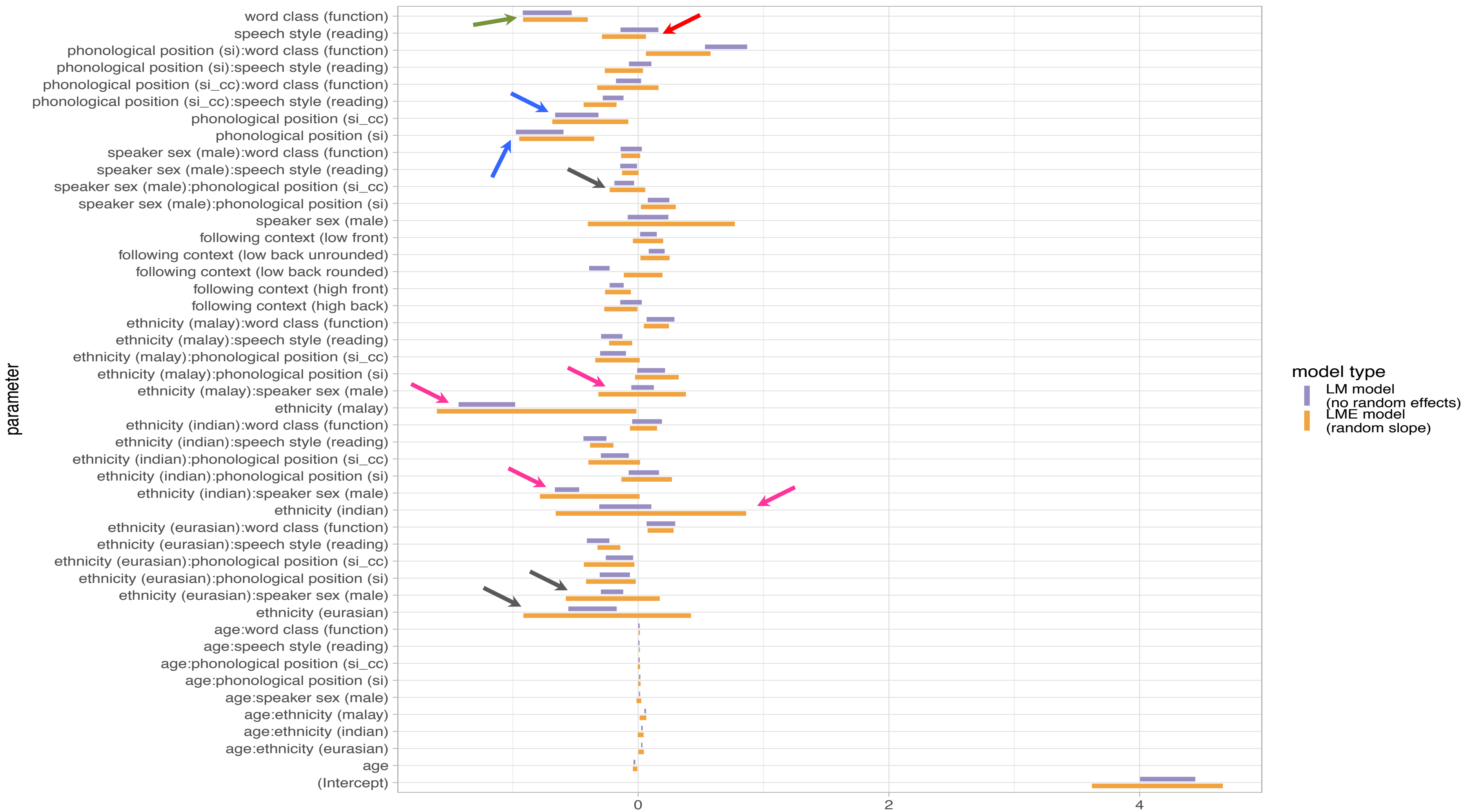

Figure 4.27: Comparison of an LM model – with no random effects (top bar; purple) and an LME random slope model – speaker random slope for phonological position and random intercept for word (bottom bar; yellow). Phonological position codes: 'si' – syllable-initial, 'si_cc' – syllable-initial consonant cluster. Arrows are explained in preceding text.

Variation in non-syllable-final /r/ realisations in SgE can therefore be summarised in the following key points:

1) The likelihood of tap/trill (i.e. Score 5) occurrences is high when:
   - /r/ precedes a high back or a low front vowel, particularly when it is an intervocalic /r/ followed by a high back vowel (e.g. *Europe*).
   - /r/ is in syllable-initial consonant clusters of function words in read speech (e.g. *everything*). This is true for both female and male SgE speakers of all four ethnic groups, except ethnically Chinese males for whom the occurrence in content words is more likely (e.g. *group*).
   - /r/ is in conversational function words, for all SgE speakers, but there is variation in the effect of phonological position for different ethnic and speaker-sex sub-groups.
2) The likelihood of strong labiodental approximant (i.e. Score 2) occurrences is high when:
   - /r/ precedes a high front or a high back vowel, particularly when it is a syllable-initial /r/ followed by a high front vowel (e.g. *really*).
   - /r/ is in syllable-initial position (and occasionally in syllable-initial consonant clusters) of content words (e.g. *racing*, *bread*) in both conversation and reading; phonological position and speech style effects vary amongst the different ethnic and speaker-sex sub-groups.
3) The likelihood of strong post-alveolar approximant (i.e. Score 4) occurrences is high when:
   - /r/ precedes a low back rounded or a low back unrounded vowel, particularly when it is a syllable-initial /r/ followed by a low back rounded vowel (e.g. *rotten*).
   - /r/ is in intervocalic position of content words (e.g. *carry*) in both reading and conversation, and syllable-initial position of function words (e.g. *rather*); phonological position, word class, and speech style effects vary amongst the different ethnic and speaker-sex sub-groups.
4) Analyses of the behaviours of the four main ethnic groups of SgE speakers and of the effects of interactions on null realisations (i.e. Score 0), weak and strong labiodental approximants (i.e. Scores 1 and 2), and weak and strong post-alveolar approximants (i.e. Scores 3 and 4) in read speech further support the recurring hypothesis that syllable-initial consonant clusters contribute to the occurrence of perceptually

weaker /r/ realisations and that this is a naturally-occurring language-internal process consistent throughout the SgE community.

5) SgE speakers from different ethnic and speaker-sex groups behave more similarly, in terms of phonological position, for most /r/ realisations (i.e. Scores 0, 1, 2, 4, 5) in read speech than in conversational speech. For all SgE speakers, there are no speech style effects on phonological position effects for weak post-alveolar approximants (i.e. Score 3).
6) Female SgE speakers generally produce more perceptually weak /r/ variants (i.e. Scores 0, 1, 2, 3) while male SgE speakers generally produce more perceptually strong /r/ variants (i.e. Scores 4, 5) but interactional effects between ethnicity and speaker-sex are seen in ethnically Indian SgE speakers for whom this behavior is in a reverse pattern.

4.5 Variation in syllable-final /r/ realisations

4.5.1 Effects of linguistic and non-linguistic factors

Although SgE is traditionally known to be a non-rhotic accent, its speakers do not categorically delete syllable-final /r/, as evidenced in the overview presented in Section 4.2. However, SgE speakers who do realise syllable-final /r/ may not always do so consistently. SgE speakers who are a lot more consistent, defined by having comparatively more realisations in all three read speech types and conversation (if applicable), can be identified from the breakdown of the number of observations per speaker. Through this, the extent of inter-speaker variation in syllable-final /r/ realisation in SgE is clearly seen. Further verification is found through the investigation of individual speaker variation which was carried out by analysing by-speaker random slopes for phonological position in the LME model fitted on the full data (see Section 4.3.2 for description of the full LME model). The relevant output of this analysis is presented in Figure 4.28. The 'outliers' in Figure 4.28, who have baseline /r/ scores for the intercept (i.e. syllable-final position) that are much higher than those of all other speakers, are indeed also some of those who produce syllable-final /r/ more consistently (e.g. Speakers mf7, mf17, if10, cf17, cf20). The following results, and subsequent conclusions of possible trends and implications of syllable-final /r/ variation in

SgE are therefore derived from the data provided by these speakers who serve as representative of the various subgroups of SgE speakers.

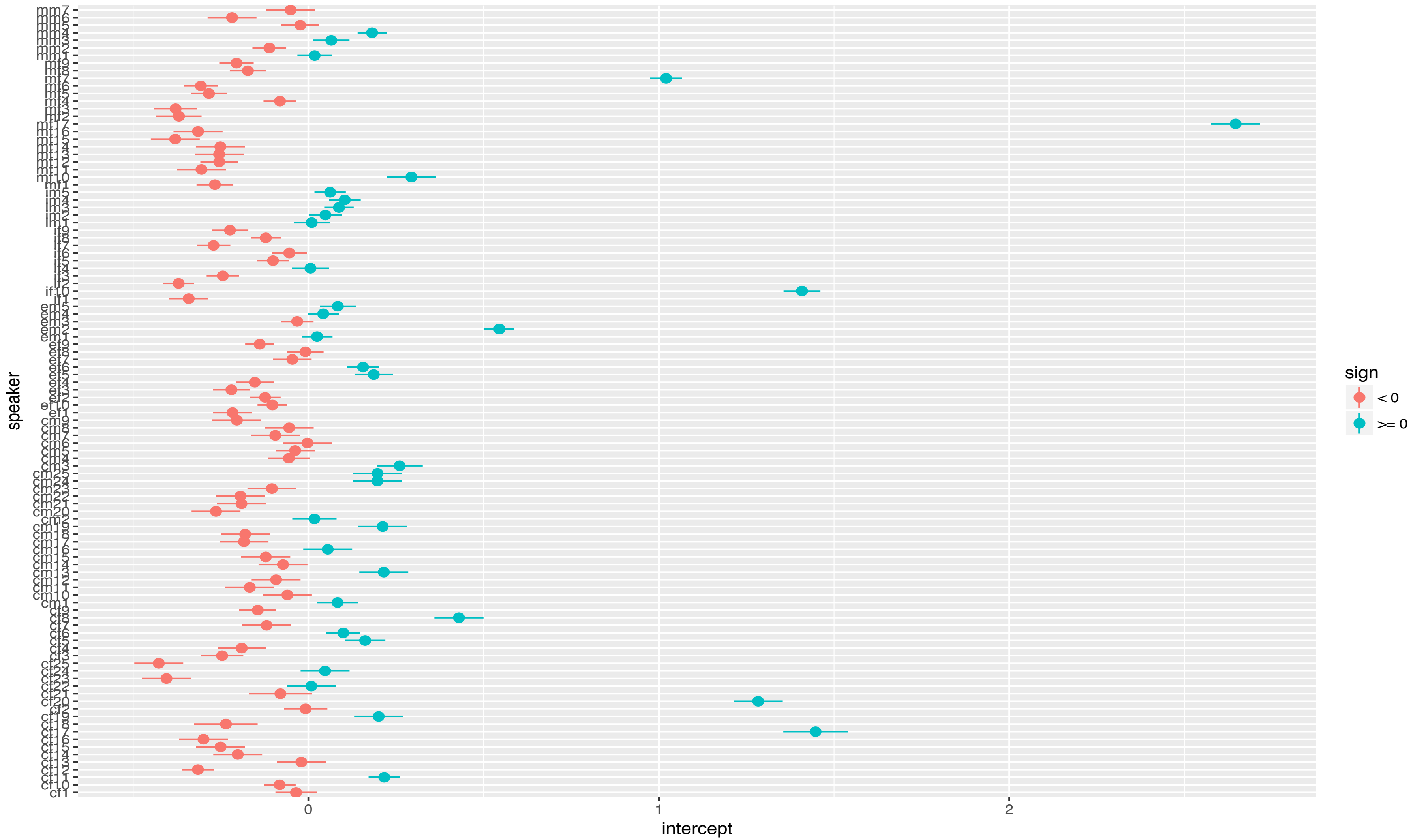

Figure 4.28: Baseline scores of /r/ realisations in syllable-final position (i.e. intercept of the LME model) for individual speakers.

As reported in Section 4.2, in SgE, /r/ is realised in all syllable-final positions, namely syllable-final non-prevocalic, syllable-final consonant cluster, and syllable-final prevocalic at word boundary (i.e. linking /r/). Intrusive /r/ also exists but since its occurrence is infrequent, as detailed in Section 4.2, no further inferential statistical analysis was carried out on the intrusive /r/ data. Both an MLR and an LME model were thus fitted to the data that included all the other syllable-final positions from both speech styles (i.e. reading and conversation). These models have the same fixed effects structure, and random effects structure where applicable, as the full model described in Section 4.3.2.

It is clear, from Figure 4.29, that while the majority of syllable-final /r/ in SgE are null realisations (i.e. Score 0), there are phonological position effects on syllable-final /r/ in SgE when they are realised. The linking /r/ (i.e. prevocalic /r/ realisation at word boundaries), contrasting entirely with the other /r/-sandhi phenomenon, the intrusive /r/, is a common occurrence in SgE. In fact, this syllable-final phonological position has the highest predicted probability of /r/ realisation (i.e. Scores 1 – 5 combined) in SgE. This is true in both reading and conversation, as well as in content words (e.g. *fear (of))* and function words (e.g. *for (a))*, as seen in Figure 4.29. Predicted probabilities of /r/ realisation (i.e. Scores 1 – 5 combined) between the other two phonological positions (i.e. syllable-final non-prevocalic, syllable-final consonant clusters) appear to be comparable and this is consistent for comparisons of occurrences within each speech style and each word class.

Here, it can also be concluded that regardless of phonological position, there is a higher predicted probability of syllable-final /r/ realisations occurring in content words than in function words. Predicted probabilities of syllable-final /r/ realisations also increase if they occur in reading instead of conversation. Analysing syllable-final /r/ realisations further, phonological position effects are also seen on the type of /r/ variants that occur (see Table 4.28). All /r/ variants (i.e. Scores 1 and 2 – weak and strong labiodental approximants, Scores 3 and 4 – weak and strong post-alveolar approximants, and Score 5 – taps/trills) have higher predicted probabilities of occurrence in syllable-final prevocalic position than in the other two syllable-final positions. Between those, there is a higher predicted probability of all /r/ variants occurring in syllable-final non-prevocalic position (e.g. *sorely*, *pure (honey)*) than in syllable-final consonant clusters (e.g. *apartment*, *absurd*). From Figure 4.29, it is clear that in all three syllable-final positions, strong post-alveolar approximant (i.e. Score 4) occurrences are the highest. As presented in Table 4.28, /r/ realisations hardly occur in syllable-final non-prevocalic position and syllable-final consonant clusters. When they do, they are mostly strong post-alveolar approximants (i.e. Score 4) and only very occasionally the weaker variant (i.e. Score 3). Labiodental approximants (i.e. Scores 1 and 2) and taps/trills (Score 5) are almost never produced in these syllable-final positions.

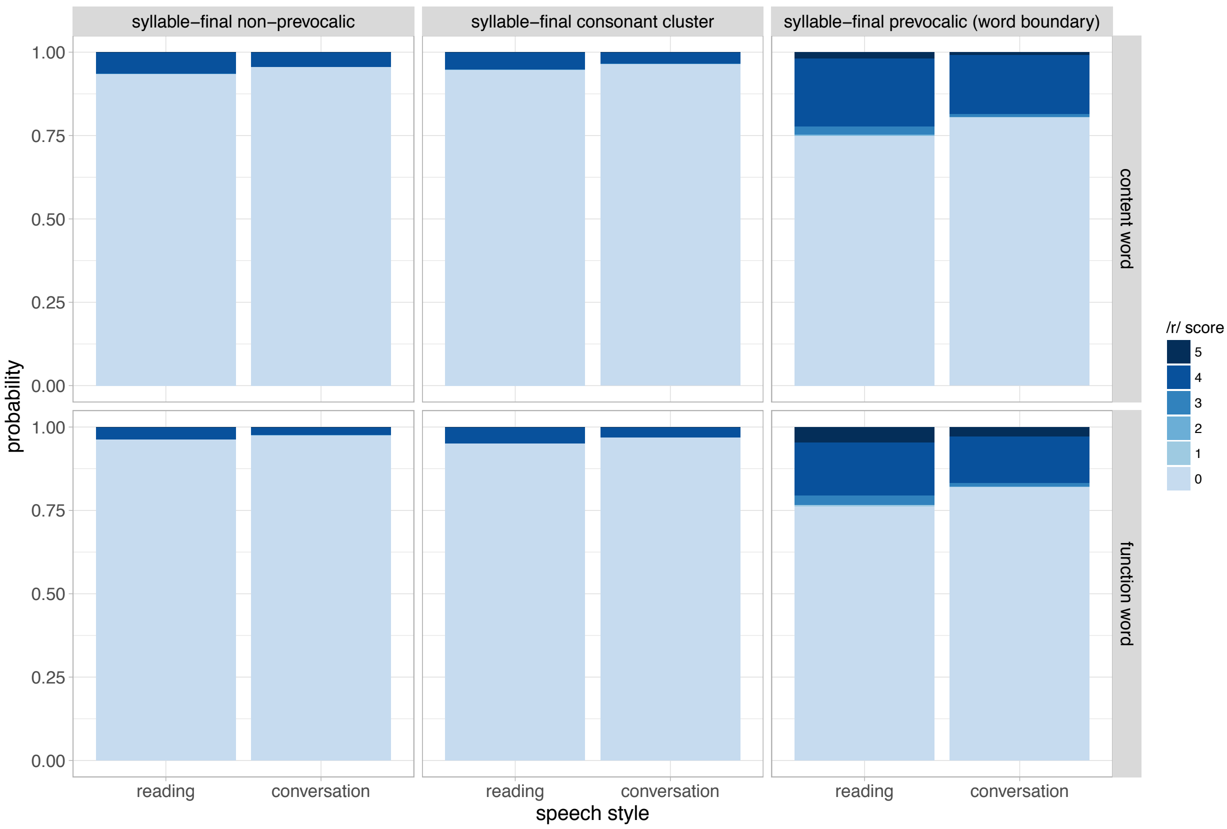

Figure 4.29: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in reading (left bars in each cell) and conversation (right bars in each cell), according to phonological position (presented in three columns, left to right – syllable-final non-prevocalic, syllable-final consonant cluster, syllable-final prevocalic (word boundary)) and word class (presented in two rows, top – content word, bottom – function word), (n = 23,862).

Table 4.28: Average predicted probabilities (rounded off to 3 decimal places), generated from the MLR model, of /r/ variants for each syllable-final phonological position and word class in read and conversational speech.

Reading							
Phonological position	**Word class**	**/r/ score**					
		5	**4**	**3**	**2**	**1**	**0**
syllable-final non-prevocalic	content	4.659E-05	0.063	0.002	1.269E-04	1.745E-04	0.935
	function	9.972E-06	0.037	0.001	1.194E-06	7.914E-05	0.963
syllable-final consonant cluster	content	1.300E-23	0.052	4.694E-04	3.571E-26	1.357E-07	0.948
	function	6.317E-23	0.049	6.689E-05	7.894E-27	9.974E-07	0.951
syllable-final prevocalic (word boundary)	content	0.018	0.204	0.025	0.003	0.001	0.750
	function	0.045	0.159	0.028	0.001	0.004	0.762

Conversation							
Phonological position	**Word class**	**/r/ score**					
		5	**4**	**3**	**2**	**1**	**0**
syllable-final non-prevocalic	content	5.667E-04	0.043	9.046E-04	9.559E-06	1.489E-10	0.956
	function	1.012E-04	0.024	3.966E-04	9.750E-08	4.716E-11	0.976
syllable-final consonant cluster	content	4.162E-24	0.034	0.001	5.390E-27	1.407E-13	0.965
	function	2.225E-23	0.030	1.386E-04	5.979E-27	7.449E-13	0.970
syllable-final prevocalic (word boundary)	content	0.008	0.177	0.008	0.001	3.915E-10	0.805
	function	0.028	0.140	0.011	0.002	1.697E-09	0.820

Since most types of /r/ variants occur at word boundaries in syllable-final prevocalic position, variation within this phonological position is analysed further. In this position, there is a clear increase in the predicted probability of a tap/trill (i.e. Score 5) occurrence and a clear decrease in that of a strong post-alveolar approximant (i.e. Score 4) if the /r/ realisation occurred in a function word (e.g. *more (in)*). This is true of both speech styles, albeit to a larger extent in reading than in conversation. It seems to suggest that, for linking /r/, SgE speakers choose to produce perceptually stronger, but less conventional, /r/ realisations (i.e. taps/trills - Score 5) more in structural words than in lexical items and conventional /r/ realisations (i.e. strong post-alveolar approximants – Score 4) more in lexical items than in structural words instead, making this distinction more in careful deliberate speech.

Effects of ethnicity on syllable-final /r/ realisations are shown in Figure 4.30 where, not considering phonological position, ethnically Malay SgE speakers, amongst all ethnic groups, have the highest predicted probabilities of realising syllable-final /r/ regardless of word form and speech style. While there is no interaction found between ethnicity and speech style as it is true across all ethnic groups that there are higher probabilities of syllable-final /r/ realisations in reading than in conversation, interaction between ethnicity and word form is seen in the Indian ethnic group. Ethnically Indian SgE speakers, unlike everyone else, have a higher probability of syllable-final /r/ realisations in function words (e.g. *more*) than in content words (e.g. *core*) in both speech styles. For all other ethnic groups (i.e. Chinese, Eurasian, Malay), syllable-final /r/ realisations are always more likely to occur in content words (e.g. *core*) than in function words (e.g. *more*) for in both read and conversational speech. What is applicable to all SgE speakers regardless of ethnicity, however, is the effect of word class on tap/trill (i.e. Score 5) realisations. There is always a higher predicted probability of producing syllable-final taps/trills (i.e. Score 5) in function words (e.g. *under*) than in content words (e.g. *blunder*) (see Figure 4.30).

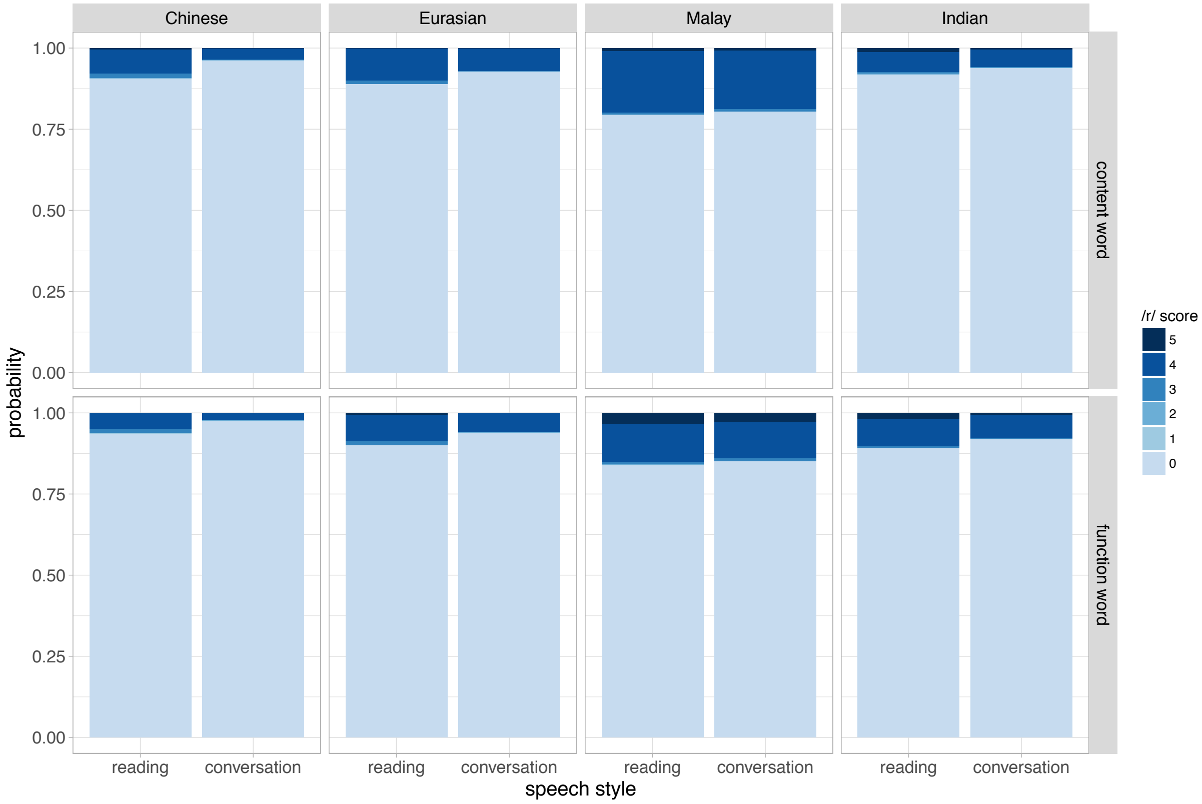

Figure 4.30: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in reading (left bars in each cell) and conversation (right bars in each cell), according to ethnicity (presented in four columns, left to right – Chinese, Eurasian, Malay, Indian) and word class (presented in two rows, top – content word, bottom – function word), (n = 23,862).

As seen in Figure 4.31, speaker sex differences pattern similarly for ethnically Chinese and Indian SgE speakers, and for ethnically Eurasian and Malay SgE speakers. For all syllable-final positions, ethnically Chinese and Indian female SgE speakers, in combined speech styles, have higher probabilities of realising syllable-final /r/ as compared to their male counterparts whereas the opposite pattern was true for ethnically Eurasian and Malay SgE speakers. Speaker sex differences for ethnically Eurasian and Malay SgE speakers, however, were small. Ethnicity and speaker sex also have effects on the predicted probability of taps/trills (i.e. Score 5) occurring in syllable-final positions. There are higher predicted probabilities of tap/trill (i.e. Score 5) occurrence for ethnically Malay and Indian SgE speakers, and also for males than for females.

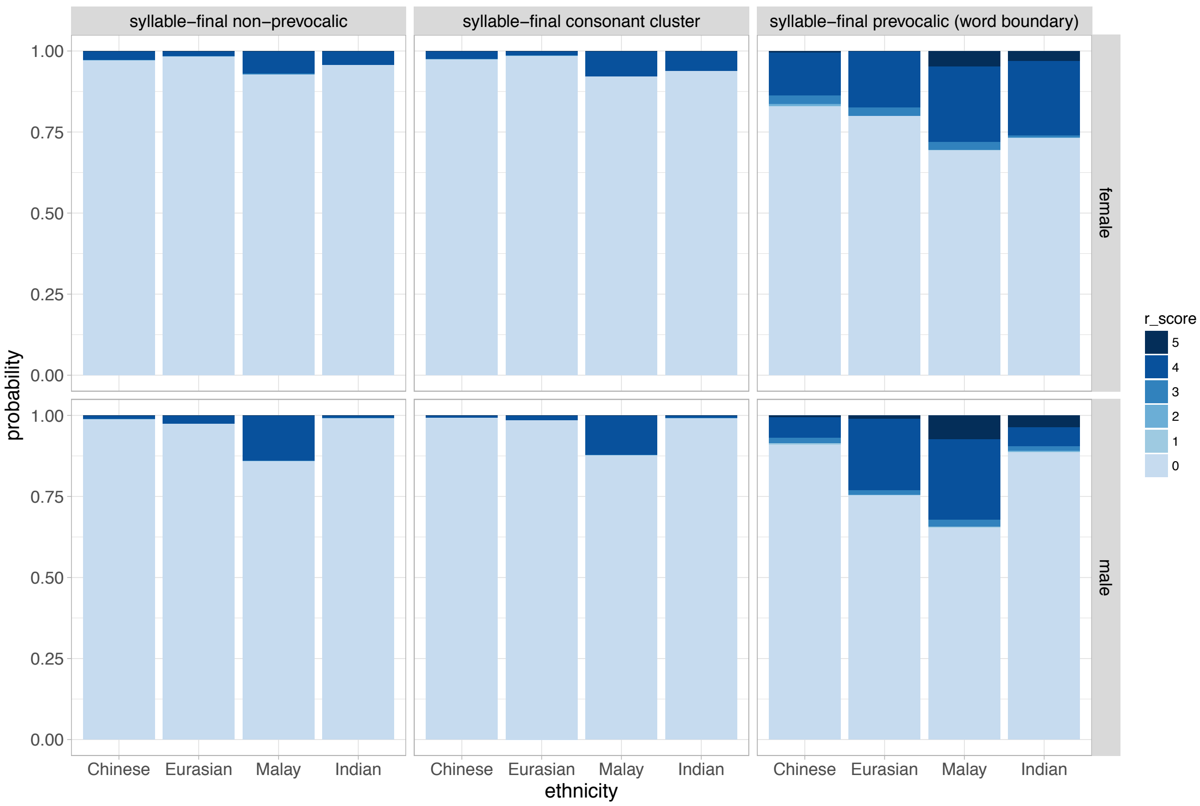

Figure 4.31: Predicted probabilities, generated from the MLR model, of /r/ variants (i.e. Score 5 – tap/trill, Score 4 – strong post-alveolar approximant, Score 3 – weak post-alveolar approximant, Score 2 – strong labiodental approximant, Score 1 – weak labiodental approximant, Score 0 – null realisation) in combined speech, according to ethnicity, phonological position (presented in three columns, left to right – syllable-final non-prevocalic, syllable-final consonant cluster, syllable-final prevocalic (word boundary)), and speaker sex (presented in two rows, top – female, bottom – male), (n = 23,862).

4.5.2 Considerations and summary of findings

The effects of ethnicity and speaker sex described, however, should be interpreted with caution as it appears that there might be variability between speakers within the subgroups of these factors. This is illustrated by the comparison of an LM model (i.e. without random structure) and an LME random slope model (i.e. with random structure) in which, for the applicable parameters, there are much wider confidence intervals (i.e. longer bottom bars; pink bars) and/or differences in direction of effects (i.e. for some parameters, only pink bars extend across the '0' mark) when random effects are considered (see sections in Figure 4.32 marked by brown arrows). Suggested here then is that deeper levels of inter-speaker differences are involved and this calls for a further consideration of individual speaker profiles to determine a more accurate conclusion for the effects of syllable-final /r/ variation in these instances. On the other hand, the effects of phonological position, speech style, and interactions between ethnicity and word class can be generalised to be representative of SgE as the directions and extents of these effects in both LME and LM models are very similar (see sections in Figure 4.32 marked by purple arrows).

Nonetheless, the following findings contribute a clearer picture of syllable-final /r/ realisation and variation in SgE:

1) /r/ is realised in all syllable-final positions (i.e. syllable-final non-prevocalic, syllable-final consonant cluster, syllable-final prevocalic at word boundary) and has the highest likelihood of occurring in syllable-final prevocalic position at word boundaries (i.e. linking /r/, e.g. *more of*). This is true in both speech styles and word classes. It is least likely to occur as intrusive /r/ (e.g. *law(r)and*).
2) Syllable-final /r/ is generally more likely to occur in content words than in function words, and in reading than in conversation.
3) When syllable-final /r/ occurs in syllable-final non-prevocalic position (e.g. *more (than)*) and in syllable-final consonant clusters (e.g. *word*), it is most likely a strong post-alveolar approximant (i.e. Score 4). It is only very occasionally a weak post-alveolar approximant (i.e. Score 3) and very rarely, if at all, labiodental approximants (i.e. Scores 1 and 2) and taps/trills (i.e. Score 5).
4) There is most variation in /r/ realisation and highest likelihoods of occurrence for each /r/ variant (i.e. Scores 1 – 5) when /r/ occurs in syllable-final prevocalic position (i.e. linking /r/).
5) Tap/trill (i.e. Score 5) occurrences in syllable-final prevocalic position (i.e. linking /r/) are more likely in function words than in content words for both read and conversational speech, albeit to a larger extent in the former speech style. This applies to all SgE speakers, regardless of ethnicity.
6) Ethnically Malay SgE speakers are most likely to realise syllable-final /r/, regardless of all linguistic factors.
7) Ethnically Indian SgE speakers, unlike those from all other ethnic groups (i.e. Chinese, Eurasian, Malay), have generally more syllable-final /r/ realisations in content words than in function words.
8) Ethnically Chinese and Indian female SgE speakers are more likely to realise syllable-final /r/ than their male counterparts while the reverse speaker-sex effect is true for ethnically Malay and Eurasian SgE speakers.

Figure 4.32: Comparison of an LM model – with no random effects (top bar; green) and an LME random slope model – speaker random slope for phonological position and random intercept for word (bottom bar; pink). Phonological position codes: 'sf_np' – syllable-final non-prevocalic, 'sf_cc' – syllable-final consonant cluster.

4.6 Key findings of the auditory analysis of Singapore English /r/ variation

The findings of the auditory analysis of both non-syllable-final and syllable-final /r/ variation in SgE are thus summarised in the following key points:

1) Three different /r/ variants (i.e. Tap/trill, Post-alveolar approximant, Labiodental approximant) and also weak-strong distinctions within the variants of approximant /r/ (i.e. weak and strong post-alveolar approximant, weak and strong labiodental approximant) are present in SgE in both non-syllable-final and syllable-final positions.
2) The post-alveolar approximant [ɹ] is the most common /r/ variant in SgE, while the labiodental approximant [ʋ] can be characterised as an emergent /r/ variant. Taps [ɾ] /trills [r] are also observably present, although they do not occur as commonly as the approximant /r/ variants.
3) The occurrences of these three variants (and also the distinctions within approximant /r/ variants) are conditioned by linguistic and non-linguistic factors, as well as the interactions between them. Each /r/ variant is conditioned in different ways and to varying extents.
4) Due to the multicultural, multilingual environment in which SgE resides, a multidimensional approach needs to be taken in the analyses of factors that determine /r/ variation in SgE.
5) One of the more outstanding findings is that syllable-initial consonant clusters play a significant role in conditioning perceptually weaker /r/ realisations (i.e. null realisations, weak labiodental approximants, weak post-alveolar approximants) and that this has surfaced to be consistent amongst SgE speakers from all four major ethnic groups (i.e. Chinese, Eurasian, Malay, Indian), thus giving evidence for it to be a naturally-occurring language-internal process. There is also evidence that having the /r/ in a function word or followed by a mid-central vowel will significantly increase the likelihood of a weaker /r/ realisation.
6) SgE speakers generally behave more similarly for most non-syllable-final /r/ realisations in read speech than in conversational speech. There are no differences between speech styles in phonological position effects on weak post-alveolar approximants (i.e. Score 3).

7) In non-syllable-final positions, most female SgE speakers generally produce more perceptually weak /r/ variants (i.e. Scores 0, 1, 2, 3) while most male SgE speakers generally produce more perceptually strong /r/ variants (i.e. Scores 4, 5).
8) Interactional effects between ethnicity and speaker-sex are seen in ethnically Indian SgE speakers. In this ethnic group, males produce more perceptually weak /r/ variants while females produce more perceptually strong /r/ variants.
9) Individual speaker differences need to be taken into account before making generalisations about the effects of ethnicity and speaker-sex.
10) The linking /r/ (i.e. syllable-final prevocalic /r/ at word boundaries) is the most common syllable-final /r/ in SgE and the intrusive /r/ is the least common.
11) Syllable-final /r/ is generally more likely realised in read speech than in conversational speech and more in content words than in function words. A slight exception is found in ethnically Indian SgE speakers who have more syllable-final /r/ realisations in function words than in content words for both speech styles.
12) Ethnically Malay SgE speakers have the highest probability of realising syllable-final /r/.
13) There appears to be effects of interaction between ethnicity and speaker-sex in the realisation of syllable-final /r/ - there are higher likelihoods for syllable-final /r/ realisations by ethnically Chinese and Indian female SgE speakers than by their male counterparts while it is the reverse speaker-sex effect for ethnically Malay and Eurasian SgE speakers.
14) Ethnicity and speaker-sex effects need to be considered with caution, though, as statistical analyses highlight the possibility of individual speaker differences.

This chapter, through the results obtained from the auditory analysis of the data collected, has described various levels of both linguistic and non-linguistic effects on /r/ realisation and distribution in SgE. It has also surfaced the necessity of a multidimensional approach in analysing /r/ variation in SgE due to interactions between factors. Differences of effects were indeed found between the /r/ variants, supporting the validity of the categories assigned to them through the auditory perceptual strength index. The next chapter builds on this and focuses mainly on the approximant /r/ variants with a dual goal of further validating the auditory categories acoustically and also providing even finer details of acoustic and social variation both between and within approximant /r/ variants in SgE.

Chapter Five

Acoustic Analysis and Results: Approximant /r/

The labiodental approximant /r/ and post-alveolar approximant /r/ are found to be the most frequently occurring /r/ sounds in SgE. They have been shown to be both auditorily and acoustically distinct (Kwek, 2012) and are found in the auditory analysis of this study to be conditioned by various linguistic and non-linguistic factors. The purpose of this acoustic analysis of the approximant /r/ in SgE is therefore twofold. It first serves to validate the gradient nature of both approximant /r/ variants, represented by the further categorisation of weak and strong variants in the perceptual strength index as presented in Chapter Four (i.e. weak versus strong variants of both labiodental and post-alveolar approximants – Score 1 versus Score 2 and Score 3 versus Score 4). It also aims to quantify non-linguistic differences within and between the labiodental and post-alveolar approximant /r/ through acoustic evidence. The acoustic analysis included measuring F2 and F3 of a subset of non-syllable-final /r/ tokens categorised as Scores 1 (i.e. weak labiodental approximant), 2 (i.e. strong labiodental approximant), 3 (i.e. weak post-alveolar approximant), and 4 (i.e. strong post-alveolar approximant) in the auditory analysis. From these, distances between F2 and F3 (i.e. F3-F2 distance), transitions of F2 from /r/ to the following context (i.e. F2 transition) and transitions of F3 from /r/ to the following context (i.e. F3 transition) were then calculated. Details of measurements and calculations are as described in Section 3.4.

In this chapter, a comparison of acoustic differences between /r/ tokens in read speech categorised as Scores 1, 2, 3, and 4 in the auditory analysis is first presented. The rest of the chapter looks at the strong variants of both approximant /r/ realisations (i.e. Score 2 – strong labiodental approximant and Score 4 – strong post-alveolar approximant) in both read and conversational speech, and presents analyses of the effects of speech style and ethnicity on the acoustic measurements of each variant. While a lowered F3 is often cited as a characteristic acoustic feature of the approximant /r/ (Hayward, 2000), it has been found that F3 is not categorically lowered. Approximant /r/ is also potentially characterised by just a raised F2 (Dalcher, Knight, & Jones, 2008). This seems to suggest that what is important in the analysis of approximant /r/ is also the proximity between F2 and F3. Additionally, a narrowed F3-F2 distance has long been referred to as an acoustic characteristic of approximant /r/ (e.g.

Dalston, 1975; Delattre & Freeman, 1968; Lehiste, 1964; McGovern & Strange, 1977), thus validating the consideration of F2 and F3-F2 distance when investigating the acoustic features of approximant /r/. It appears, then, that the salience of acoustic cues is dependent on a range of factors - which approximant /r/ variants (e.g. post-alveolar or labiodental) are involved in the comparison/contrast, which other approximants are taken into consideration as well (e.g. /w/) and the variants of /r/ present/absent in the speakers'/listeners' linguistic environment (Dalcher, Knight, & Jones, 2008). Therefore, bearing all these, which have been discussed in more detail in Chapter Two, in mind and since distinctions in F3 and F3 transition between approximant /r/ variants in SgE have already been found in previous research (Kwek, 2012), this study moves a step further and focuses on the analysis of F3-F2 distance while also considering the potential contribution(s) of the other acoustic cues (i.e. F2, F3, F2 and F3 transitions), wherever applicable, in the acoustic study of /r/ variation in SgE.

5.1 Acoustic differences between variants of approximant /r/ in Singapore English

5.1.1 Comparing Scores 1 – 4 in read speech

Figure 5.1 plots the F3-F2 distances of the four scores (i.e. Score 1 – weak labiodental approximant, Score 2 – strong labiodental approximant, Score 3 – weak post-alveolar approximant, and Score 4 – strong post-alveolar approximant) in non-syllable-final positions from read speech data for both female and male SgE speakers while illustrated in Figure 5.2 are the corresponding average F2 and F3 readings of each approximant /r/ variant. It should be noted that the F2 and F3 markers of each variant in Figure 5.2 are only joined to facilitate visual coherence and do not have other implications.

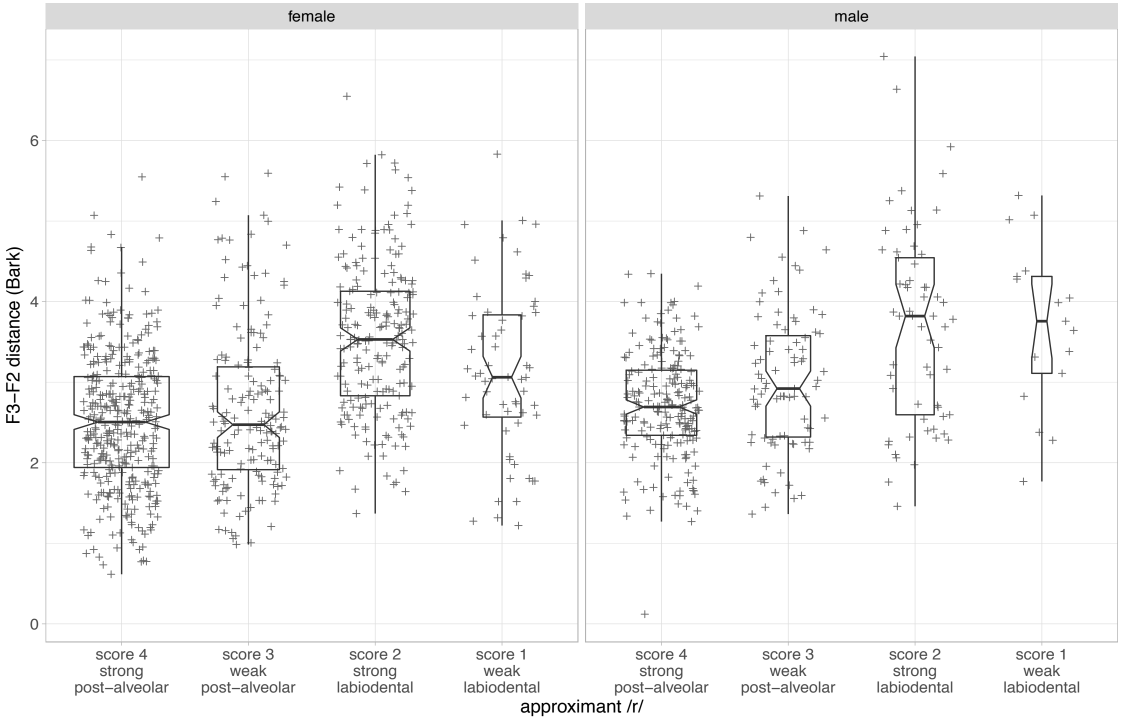

Figure 5.1: F3-F2 distances (Bark) of each approximant /r/ variant in read speech, according to speaker sex (columns from left to right: female, male), (*n* = 1166).

Comparing the medians of each variant, represented by the darkened middle horizontal line in each box (see Figure 5.1), observable differences in the F3-F2 distances can be seen. The notches in the boxplots represent the 95% confidence interval of the median and if the notches of boxes do not overlap, 'strong evidence', according to Chambers, Cleveland, Kleiner, & Tukey (1983), can be concluded for differences. It is clear that the notches of the boxes for comparisons between the strong variants of both types of approximant /r/ (i.e. Score 2 – strong labiodental approximant versus Score 4 – strong post-alveolar approximant) for both female and male SgE speakers do not overlap, signaling evident differences between the F3-F2 distances of the two approximant /r/ variants throughout the SgE community.

However, there are variations between speaker sex groups for the distinctions between weak and strong variants of both types of approximant /r/. While the comparison between weak and strong post-alveolar approximants (i.e. Score 3 versus Score 4) shows just a bit of an overlap of notches for the two by male SgE speakers, there is a clear overlap in the notches of their boxes for female SgE speakers. This thus implies that for male SgE speakers, F3-F2 distances of weak and strong post-alveolar approximant /r/ are likely to only be somewhat different and for female SgE speakers, it is difficult to claim any difference in F3-F2 distance between weak and strong variants of the post-alveolar approximant /r/. In a reverse pattern, there is an obvious overlap of notches for weak and strong labiodental approximant /r/ (i.e. Scores 1 and 2) for male SgE speakers but no overlap at all for female SgE speakers. Therefore, there is no evidence of differences in F3-F2 distance between weak and strong labiodental approximant /r/ for male SgE speakers but clear evidence of differences for female SgE speakers.

The wider notches displayed by Score 1 (i.e. weak labiodental approximant) for both female and male SgE speakers indicate larger distances between the median F3-F2 distance and the 75 percentile (i.e. upper horizontal line of the box) and 25 percentile (i.e. lower horizontal line of the box) for Score 1 than for Scores 2, 3, and 4 (i.e. strong labiodental approximant, weak and strong post-alveolar approximants) which had narrower notches. Such wider notches are also displayed by Score 2 (i.e. strong labiodental approximant) for male SgE speakers. This shows that there is a wider range of F3-F2 distances for Score 1 (i.e. weak labiodental approximant) tokens in the sample and for Score 2 (i.e. strong labiodental approximant) tokens of male SgE speakers. Score 1 for both female and male SgE speakers and Score 2 for male SgE speakers also have slimmer boxes and fewer data points as compared to the other scores. These are indications of a smaller sample size. Therefore, as this means that the sample size for Score 1 (i.e. weak labiodental approximant) is relatively small and the F3-F2 distances of the tokens which are categorised as Score 1 are quite varied, there is a need to exercise caution when interpreting results of analyses for Score 1 as they may not be entirely representative of the sample. Also, there appears to be differences between speaker sex where the findings of F3-F2 distance for Score 2 (i.e. strong labiodental approximant) are stable and reliable for female but not for male SgE speakers, and little differences between the F3-F2 distance of Scores 3 and 4 (i.e. weak and strong post-alveolar approximant) and more differences between that of Scores 1 and 2 (i.e. weak and strong labiodental approximant) for female SgE speakers but the exact reverse for male SgE speakers.

Additionally, from Figure 5.2, some further general observations can be made. It is seen that the wider F3-F2 distances for both weak and strong labiodental approximants (i.e. Scores

1 and 2) as compared to their post-alveolar counterparts, as seen in Figure 5.1, are the outcomes of the joint workings of a low F2 and a high F3. These are true for both female and male SgE speakers and are in line with descriptions of labiodental approximant realisations.

In the case of female SgE speakers, the comparison of F3-F2 distances between the weak and strong variants of the labiodental approximant /r/ (i.e. Scores 1 and 2) was initially unexpected. However, through the analysis of F2 and F3 behaviours of all approximant /r/ variants, the findings are resultantly justifiable. The narrower F3-F2 distance for Score 1 (i.e. weak labiodental approximant) than for Score 2 (i.e. strong labiodental approximant) can be seen, in Figure 5.2, to be caused by a higher F2 and lower F3 in the former. This seemed counterintuitive at first. However, upon further comparative analyses with both the weak labiodental approximant (i.e. Score 1) and the post-alveolar approximant /r/ (i.e. Scores 3 and 4), it appears that a lower F2 for Score 2 (i.e. strong labiodental approximant) could be due to the fact that, being the stronger realisation of the two labiodental variants, Score 2, theoretically, has a stronger labial quality, and therefore lower F2, than Score 1. F2 for Score 2 (i.e. strong labiodental approximant), nonetheless, is not exceptionally low and remains in close proximity to the F2 of Score 4 (i.e. strong post-alveolar approximant). This is hypothesized to be a reflection of the maintained /r/ quality and similarity to the strong post-alveolar approximant (i.e. Score 4), as the strong labiodental approximant /r/ (i.e. Score 2) does not have the typical lowered F3 characteristic of an approximant /r/ - in fact, F3 of Score 2 is the highest amongst all other scores (i.e. all other variants of approximant /r/), presumably a result of the combination of higher labial quality and lesser tongue retroflexion. Taken together, these are posited as contributing to the perception of Score 2 (i.e. strong labiodental approximant) as an /r/ variant and not a /w/ which is typically characterised by a high F3 and low F2, while at the same time as a distinct variant of approximant /r/ different from the others (i.e. Scores 1, 3, 4).

Differences in F3-F2 distance of Scores 1 and 2 (i.e. weak and strong labiodental approximants) are minimal for male SgE speakers, unlike for female SgE speakers as described above. However, from the wide notches and small number of data points, as seen in Figure 5.1, the strength of reliability of the findings must be considered carefully. Figure 5.2, nonetheless, reveals some details of F2 and F3 behaviour of the two labiodental approximant variants (i.e. Scores 1 and 2) in comparison to the two post-alveolar approximant variants (i.e. Scores 3 & 4) which show some differences between the speaker-sex groups. Different from the acoustic findings for female SgE speakers, Score 1 (i.e. weak labiodental approximants) for male SgE speakers has a lower F2 and a higher F3 than Score 2 (i.e. strong labiodental approximant). F2 of Score 2 (i.e. strong labiodental approximant), however, is also quite low and remains in close proximity to F2 of Score 4 (i.e. strong post-alveolar approximant), as seen for female SgE speakers, reiterating the hypothesis that it is a reflection of the maintenance of an /r/-like quality and similarity to a strong post-alveolar approximant (i.e. Score 4) for a variant (i.e. strong labiodental approximant, Score 2) which might, otherwise, not be perceived as a strong approximant /r/ due to its higher F3. This low F2 also appears to be what differentiates the perception of Score 2 (i.e. strong labiodental approximant) from that of Score 3 (i.e. weak post-alveolar approximant) since both have relatively similar F3s which are distinctively higher than that of Score 4 (i.e. strong post-alveolar approximant) and lower than that of Score 1 (i.e. weak labiodental approximant).

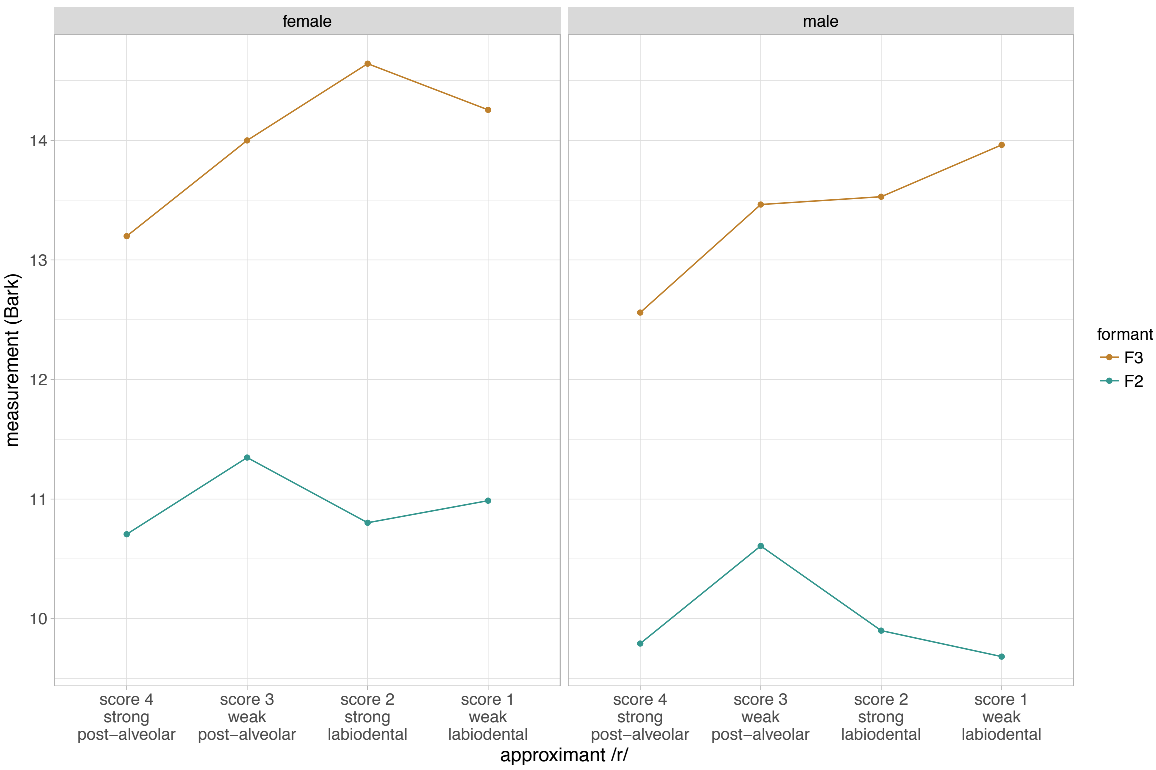

Figure 5.2: Average F2 and F3 (Bark) of each approximant /r/ variant in read speech, according to speaker sex (columns from left to right: female, male).

Since research (e.g. Dalcher et al., 2008; Heselwood & Plug, 2011) has found lowered F3 to not always be a reliable sole measure in studying /r/ realisations, F3 transition and F2 transition were subsequently analysed for both speaker sex groups as well. Figures 5.3 and 5.4 plot the average F3 and F2 transitions respectively. The difference in F3 transitions between the weak and strong labiodental approximant (i.e. Scores 1 and 2) is what was expected from previous studies of the labiodental /r/ in SgE (Kwek, 2012). A larger F3 transition for the strong labiodental approximant reflects a stronger /r/ articulation than the weak labiodental approximant as seen in Figure 5.3. This applies to both female and male SgE speakers.

While interpreting the roles of F2 and F3 transitions in cueing the auditory perception of /r/, however, those of the following context needs to be considered as well. This can be seen in the analysis of F2 transitions of the two labiodental approximants (i.e. Scores 1 and 2) for both female and male SgE speakers. While a larger F2 transition in the strong labiodental approximant (i.e. Score 2) (see Figure 5.4) seems to suggest a more /w/-like target for the strong labiodental approximant than for the weak labiodental approximant, a closer observation of the segments involved showed that this might not be the case (see Figure 5.5). A /w/ is marked by a distinctively lower F2 (Dalcher et al., 2008) and therefore it is expected that a more /w/-like target would be too. However, as seen in Figures 5.2 and 5.5, the F2 values of both labiodental approximants are either very similar (for female SgE speakers) or Score 1 (i.e. weak post-alveolar approximant) actually has a lower F2 than Score 2 (i.e. strong post-alveolar approximant) (for male SgE speakers). The larger F2 transition in the strong labiodental approximant (i.e. Score 2) in fact appears to be caused by the exceptionally higher F2 value of its following context. Again, this is true for both female and male SgE speakers. High front vowels were found, in the auditory analysis to make up the majority of the strong labiodental approximant's (i.e. Score 2's) following contexts while the weak labiodental approximant (i.e. Score 1) preceded mostly low back vowels, thus showing that the auditory perception of a strong labiodental approximant (i.e. Score 2) was indeed conditioned by the following context, in particular high front vowels.

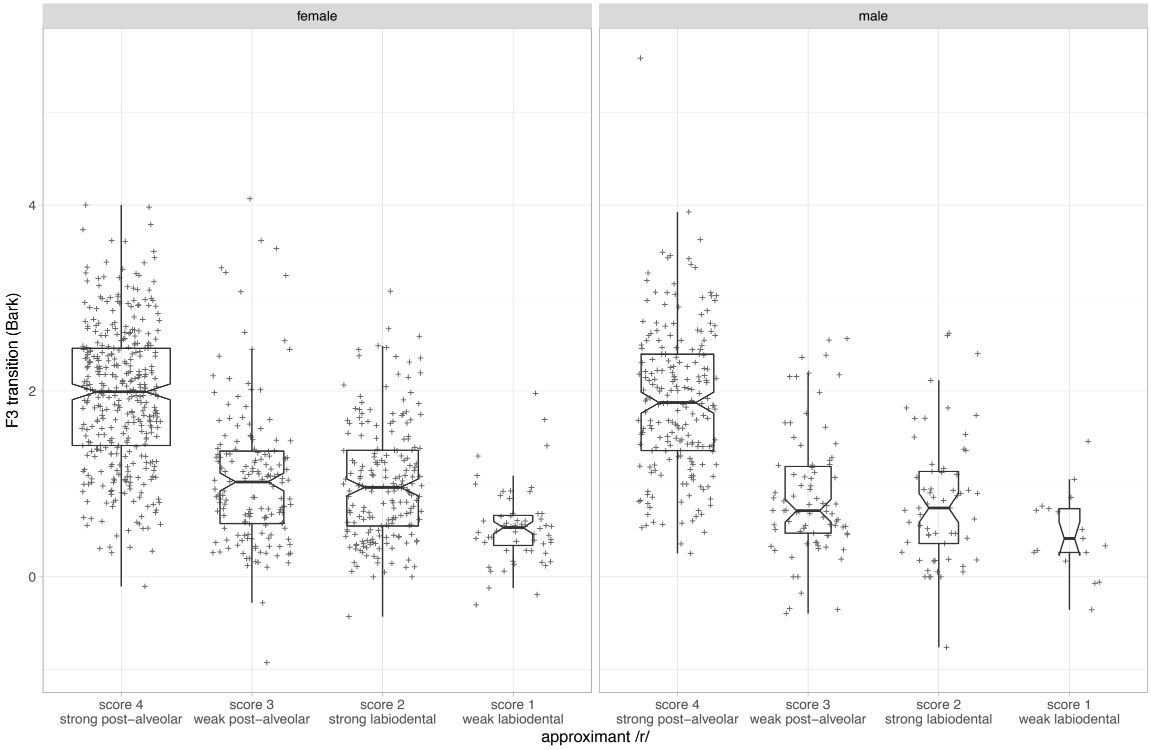

Figure 5.3: F3 transitions (Bark) of each approximant /r/ variant in read speech, according to speaker sex (columns from left to right: female, male), (*n* = 1166).

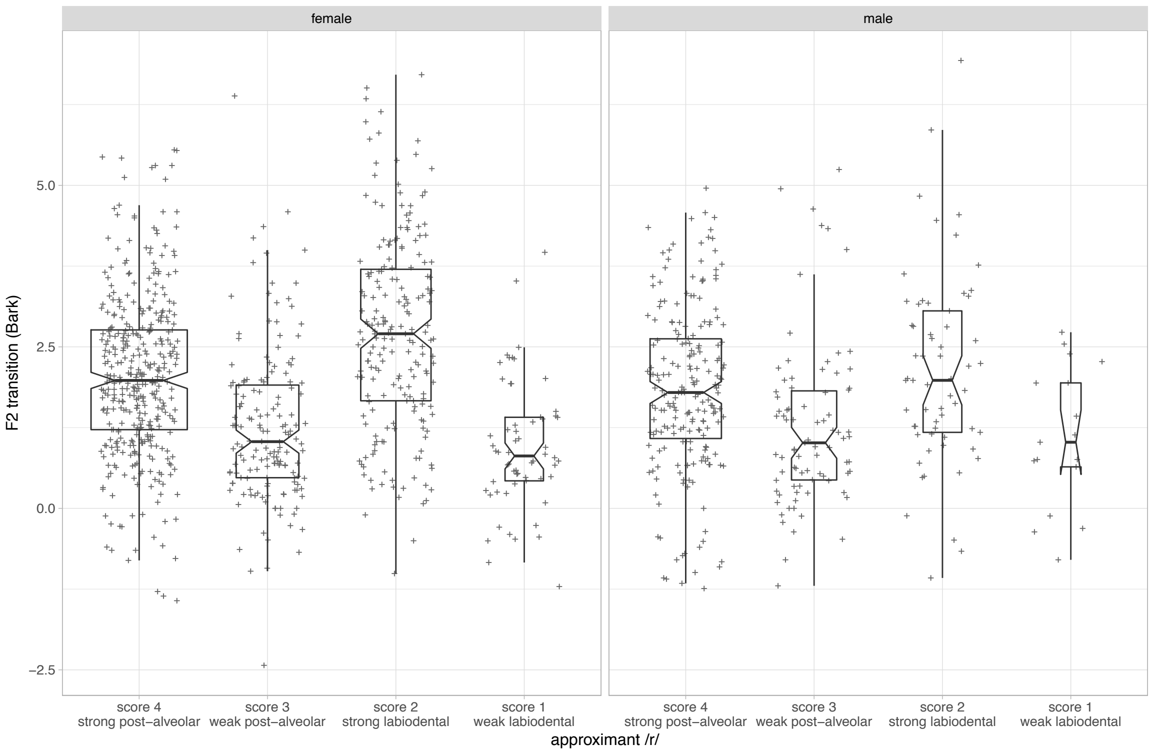

Figure 5.4: F2 transitions (Bark) of each approximant /r/ variant in read speech, according to speaker sex (columns from left to right: female, male), (*n* = 1166).

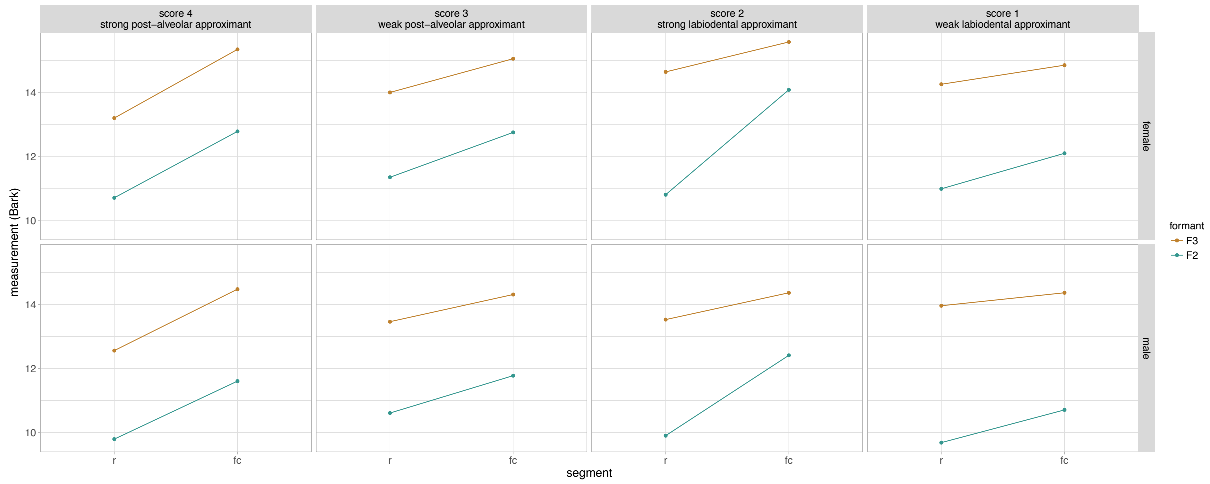

Figure 5.5: Graphical representation of F2 and F3 transitions (Bark) of each approximant /r/ variant in read speech, according to speaker sex (rows from top to bottom: female, male) (Segment codes: 'r' - /r/, 'fc' - following context).

Comparing the weak post-alveolar approximant (i.e. Score 3) and its strong variant (i.e. Score 4), expected differences in F2, F3 and F3-F2 distance are seen. Perceptually strong post-alveolar approximants have lower F2 and F3 as well as narrower F3-F2 distance than perceptually weak post-alveolar approximants. Observations of F2 and F3 are applicable to both female and male SgE speakers while that of F3-F2 distance is only true for male SgE speakers – there is hardly any difference between the F3-F2 distances of the strong and weak post-alveolar approximants for female SgE speakers. F3 transition and F2 transition of both strong and weak post-alveolar approximants for all SgE speakers are also representative of their differences (i.e. larger transitions for the strong post-alveolar approximant than the weak post-alveolar approximants). These can be said to not be affected by following contexts as both F2 and F3 of the following contexts of both post-alveolar approximants are relatively similar (see Figure 5.5), thus validating the auditory categorisation of the two post-alveolar approximants according to strength.

The results discussed here point to the relative stability of the post-alveolar approximant in SgE for both female and male speakers, having strong and weak variants that are both perceptually and acoustically distinct. The labiodental approximant, on the other hand, showed more acoustic variability which could be due to the fact that it is an emergent /r/ variant and therefore had fewer samples in the data as well as less consistent characteristics.

Nonetheless, acoustic evidence that substantiate the gradient nature of approximants in SgE as represented in the perceptual strength index is shown.

Since a pilot study done on a subset of this study's data has found some ethnicity-determined acoustic variation in approximant /r/ (Kwek, 2015), a further analysis on ethnicity-specific comparisons between weak and strong variants of both realisations of approximant /r/ (i.e. Score 1 – weak labiodental versus Score 2 – strong labiodental, and Score 3 – weak post-alveolar versus Score 4 – strong post-alveolar) was conducted and this was found to be necessary as it revealed various details that are otherwise masked. This is illustrated in Figure 5.6.

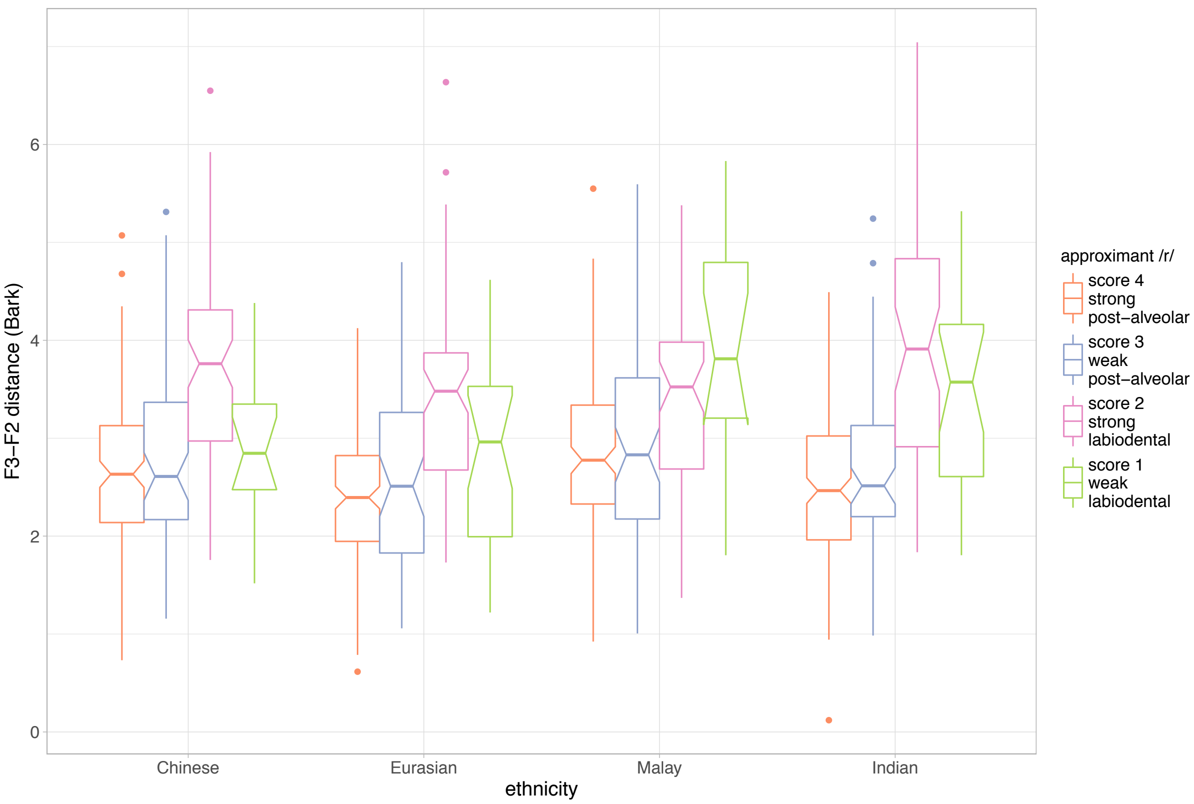

Figure 5.6: Ethnic-specific comparisons of F3-F2 distances for each approximant /r/ variant in read speech, (n = 1166).

To further verify these observations, an LME model was fitted to the data which consisted of non-syllable-final /r/ (Scores 1 – 4) in reading. It had age, speaker sex, word class, phonological position, following context, and /r/ score-ethnicity interaction, as fixed effects, and a random effects structure that included random intercepts for speaker and word, and a by-speaker random slope for phonological position. As with the LME analyses conducted for the auditory analysis, the model was fitted by REML and t-tests used Satterthwaite approximation to degrees of freedom. These were performed using the *lmer* function in the lme4 (Bates et al., 2017) and lmerTest (Kuznetsova, Brockhoff, & Christensen, 2016) packages, in R (R Core Team, 2016).

An analysis of the comparison between the weak and strong variants of labiodental approximation /r/ (i.e. Scores 1 and 2) across all ethnic groups reveals differences between the F3-F2 distances of the two, albeit non-significance as shown in Table 5.1. What stands out here, nonetheless, is the direction of the effect on ethnically Malay SgE speakers (see Figure 5.6 and Table 5.1). While the F3-F2 distance of strong labiodental approximants (i.e. Score 2) is wider than that of Score 1 for ethnically Chinese, Eurasian, and Indian SgE speakers, as illustrated in Figure 5.6 and evidenced by the negative estimates for Score 1 when compared to Score 2 (reference level) in Table 5.1, the opposite is true for ethnically Malay SgE speakers. The positive estimate for Score 1 when compared to Score 2 for ethnically Malay SgE speakers (see Table 5.1) implies that the F3-F2 distance of Score 2 is narrower than that of Score 1 for this group. This then shows that although sample size could have affected significance levels when comparisons are made between Scores 1 and 2, effects of ethnicity are still detectable. The effect of this interaction between /r/ score and ethnicity on F3-F2 distance is more clearly illustrated in Figure 5.7. There was a high standard error in the LME analysis, however, therefore more evidence for Score 1 needs to be collected in order to make generalisations and give reasons for the effects.

Table 5.1: Comparisons of F3-F2 distances for Score 1 and Score 2 (reference level) within each ethnicity in read speech, generated from the LME random slope model (/r/ score-ethnicity interaction) (values rounded off to 3 decimal places).

	Estimate	**Standard Error**	**df**	***t* value**	**Pr(>|*t*|)**	**Significance**
Chinese						
(Intercept)	2.985	0.391	21.6	7.640	1.41e-07	***
Score 1	-0.411	0.219	896.8	-1.882	0.060	
Eurasian						
(Intercept)	2.781	0.399	23.3	6.967	3.94e-07	***
Score 1	-0.135	0.173	1048.3	-0.781	0.435	
Malay						
(Intercept)	3.025	0.391	21.6	7.746	1.14e-07	***
Score 1	0.189	0.209	1063.4	0.904	0.366	
Indian						
(Intercept)	2.954	0.412	26.1	7.168	1.28e-07	***
Score 1	-0.077	0.196	928.2	-0.393	0.695	

Significance codes: ‘***’ $p < 0.001$, ‘**’ $p < 0.01$, ‘*’ $p < 0.05$

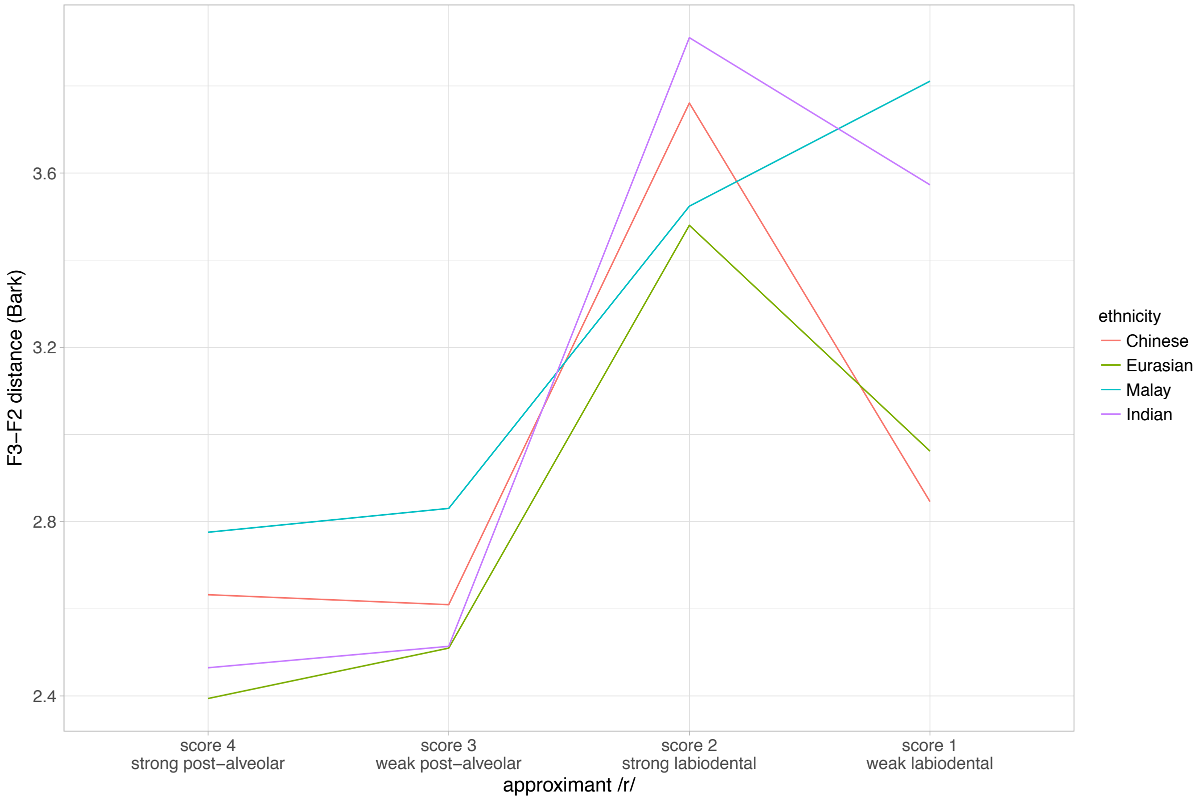

Figure 5.7: Effects of interaction between /r/ score and ethnicity on F3-F2 distances of each approximant /r/ variant in read speech.

Unlike the comparison between Scores 1 and 2, the direction of ethnicity effect on the comparison between Scores 3 and 4 is the same across ethnic groups; only the extent of effect is different. Higher medians for Score 3 (see Figure 5.6) and positive estimates for Score 3 when compared to Score 4 (see Table 5.2) for all ethnic groups indicate that the F3-F2 distance of Score 3 is wider than that of Score 4 for all SgE speakers, regardless of ethnicity. Although this appears not to be significant in the box plot (see Figure 5.6) as the overlapping of notches suggest, significant differences are revealed for most ethnic groups - ethnically Chinese ($p < .05$), Eurasian ($p < .05$), and Indian ($p < .001$) (see Table 5.2). These results once again show that perceptually different post-alveolar approximant /r/ tokens (i.e. Score 3 - weak post-alveolar approximant and Score 4 – strong post-alveolar approximants) do indeed have significant acoustic differences as well.

Table 5.2: Comparisons of F3-F2 distances for Score 3 and Score 4 (reference level) within each ethnicity in read speech, generated from the LME random slope model (/r/ score-ethnicity interaction) (values rounded off to 3 decimal places).

	Estimate	**Standard Error**	**df**	***t* value**	**Pr(>|*t*|)**	**Significance**
Chinese						
(Intercept)	2.233	0.380	19.3	5.879	1.08e-05	***
Score 3	0.300	0.118	993.4	2.550	0.011	*
Eurasian						
(Intercept)	1.846	0.389	21.1	4.744	1.09e-04	***
Score 3	0.272	0.118	1041.6	2.311	0.021	*
Malay						
(Intercept)	2.330	0.381	19.5	6.123	6.20e-06	***
Score 3	0.201	0.116	1041.6	1.726	0.085	
Indian						
(Intercept)	1.939	0.399	23.0	4.857	6.64e-05	***
Score 3	0.474	0.116	931.2	4.080	4.90e-05	***

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

Considering ethnicity effects also reiterates the fact that the F3-F2 distance of Score 2 is categorically wider than that of Score 4 (p < .001) (see Table 5.3) in SgE. This is seen, illustrated in Figure 5.6, for all four ethnic groups. From this, it is possible to conclude that in SgE, strong labiodental approximants (i.e. Score 2) and strong post-alveolar approximants (i.e. Score 4) are not only perceptually distinct but also have acoustically significant differences between them for all speakers.

Table 5.3: Comparisons of F3-F2 distances for Score 2 and Score 4 (reference level) within each ethnicity in read speech, generated from the LME random slope model (/r/ score-ethnicity interaction) (values rounded off to 3 decimal places).

	Estimate	**Standard Error**	**df**	***t* value**	**Pr(>|*t*|)**	**Significance**
Chinese						
(Intercept)	2.233	0.380	19.3	5.879	1.08e-05	***
Score 2	0.752	0.120	1064.4	6.265	5.40e-10	***
Eurasian						
(Intercept)	1.846	0.389	21.1	4.744	1.09e-04	***
Score 2	0.935	0.113	973.5	8.253	4.44e-16	***
Malay						
(Intercept)	2.330	0.381	19.5	6.123	6.20e-06	***
Score 2	0.695	0.120	1020.7	5.800	8.80e-09	***
Indian						
(Intercept)	1.939	0.399	23.0	4.857	6.64e-05	***
Score 2	1.015	0.132	927.2	7.670	4.35e-14	***

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

The findings of the acoustic comparisons of the labiodental and post-alveolar approximants, as well as of their weak and strong variants in read speech can thus be summarised in the following points:

- There are clear significant acoustic differences between the strong variants of both variants of approximant /r/ (i.e. Score 2, labiodental approximant /r/ and Score 4, post-alveolar approximant /r/) for all SgE speakers, regardless of ethnicity and speaker-sex groups. F3-F2 distance is wider, and F2 and F3 transitions are smaller for the labiodental approximant than for the post-alveolar approximant.

- There is generally more stability in the acoustic characteristics of both weak and strong variants of the post-alveolar approximant /r/ (i.e. Scores 3 and 4) and more acoustic variation in both weak and strong variants of the labiodental approximant /r/ (i.e. Scores 1 and 2).
- Between the weak and strong variants of post-alveolar approximant /r/ (i.e. Scores 3 and 4), there are observable differences in the various acoustic measures – the strong variant (i.e. Score 4) always has lower F2 and F3, and larger F2 and F3 transitions than the weak variant (i.e. Score 3). For male SgE speakers, F3-F2 distance between the two variants also differ – F3-F2 distance is narrower for the strong variant and wider for the weak variant. There is no evidence for difference in F3-F2 distance between the two for female SgE speakers.
- Between the weak and strong variants of labiodental approximant /r/ (i.e. Scores 1 and 2), the differences in acoustic measures are clear for female SgE speakers but due to the fact that male SgE speakers generally produce fewer labiodental approximants (i.e. small sample sizes) and also display more variation in these realisations amongst themselves, the findings are not statistically strong enough for much generalisations to be made for male SgE speakers.
- For female SgE speakers,
  1) F3-F2 distance is narrower for the weak labiodental approximant (i.e Score 1) than for the strong labiodental approximant (i.e. Score 2) and is caused by a lower F2 and higher F3 in the strong variant.
  2) F2 of the strong labiodental approximant (i.e. Score 2), although lower than that of the weak variant, does not lower past and remains in close proximity to that of the strong post-alveolar approximant (i.e. Score 4). The hypothesis here is that this is a result of the maintenance of /r/ quality and similarity to the other strong approximant /r/ (i.e. Score 4, strong post-alveolar approximant) because of the lack of a F3 lowering for the strong labiodental approximant (i.e. Score 2).
  3) F3 of the strong labiodental approximant (i.e. Score 2) is the highest amongst all the other approximant /r/ variants. Together, the behaviours of F2 and F3 contribute to the perception of a distinct approximant /r/ variant (i.e. Score 2, strong labiodental approximant) that is not a /w/, yet also unlike the other approximant /r/ variants.

- For male SgE speakers,
  1) F3-F2 distance is wider for the weak labiodental approximant (i.e Score 1) than for the strong labiodental approximant (i.e. Score 2) and is caused by a higher F2 and lower F3 in the strong variant.
  2) F2 of the strong labiodental approximant (i.e. Score 2), although higher than that of the weak variant unlike the female SgE speakers, is still quite low and also remains in close proximity to that of the strong post-alveolar approximant (i.e. Score 4). This further supports the hypothesis of the maintenance of /r/ quality and similarity to the other strong approximant /r/ (i.e. Score 4, strong post-alveolar approximant) because of the lack of a F3 lowering for the strong labiodental approximant (i.e. Score 2).
- Most SgE speakers, amongst the ethnicity and speaker sex subgroups, show similar acoustic patterns for the comparisons between approximant /r/ variants (directions of differences are the same, albeit variation in extent of differences). The only anomaly lies in the F3-F2 distance of ethnically Malay males, for which Score 1 (i.e. weak labiodental approximant) is wider than Score 2 (i.e. strong labiodental approximant). This, however, needs to be treated with caution for reasons mentioned earlier.

The dominance of Scores 2 and 4 (i.e. strong labiodental approximant and strong post-alveolar approximant) in SgE as reported in the auditory analysis and their clear acoustic differences found here in the acoustic analysis of read speech thus give reason for a finer acoustic analysis which provides insight to the effects of non-linguistic factors like ethnicity and speech style on variation between the two approximant /r/ variants in SgE. Ethnicity is a factor which, prior to the pilot of this study (Kwek, 2015), has never been studied in relation to /r/ realisation but proves to determine extent of differences between/within approximant /r/ variants as suggested in this section. The next section thus first covers a comparison between both approximants before the subsequent sections report on variation within each of them.

5.1.2 Comparing Scores 2 and 4 across speech styles

A further analysis of differences between Scores 2 and 4 (i.e. strong labiodental approximant and strong post-alveolar approximant) involved both read and conversational speech in SgE and tested for the effects of ethnicity and speech style on the F3-F2 distances of the two scores. An LME random slope model with the same fixed and random effects as those described for the earlier analyses but with the inclusion of a three-way interaction, /r/ score-ethnicity-speech style, was fitted to the data of only Scores 2 and 4 (i.e. strong labiodental approximant and strong post-alveolar approximant) from non-syllable-final positions and both speech styles. Figure 5.8 plots Scores 2 and 4 (i.e. strong labiodental approximant and strong post-alveolar approximant) of each ethnic group for both read and conversational speech.

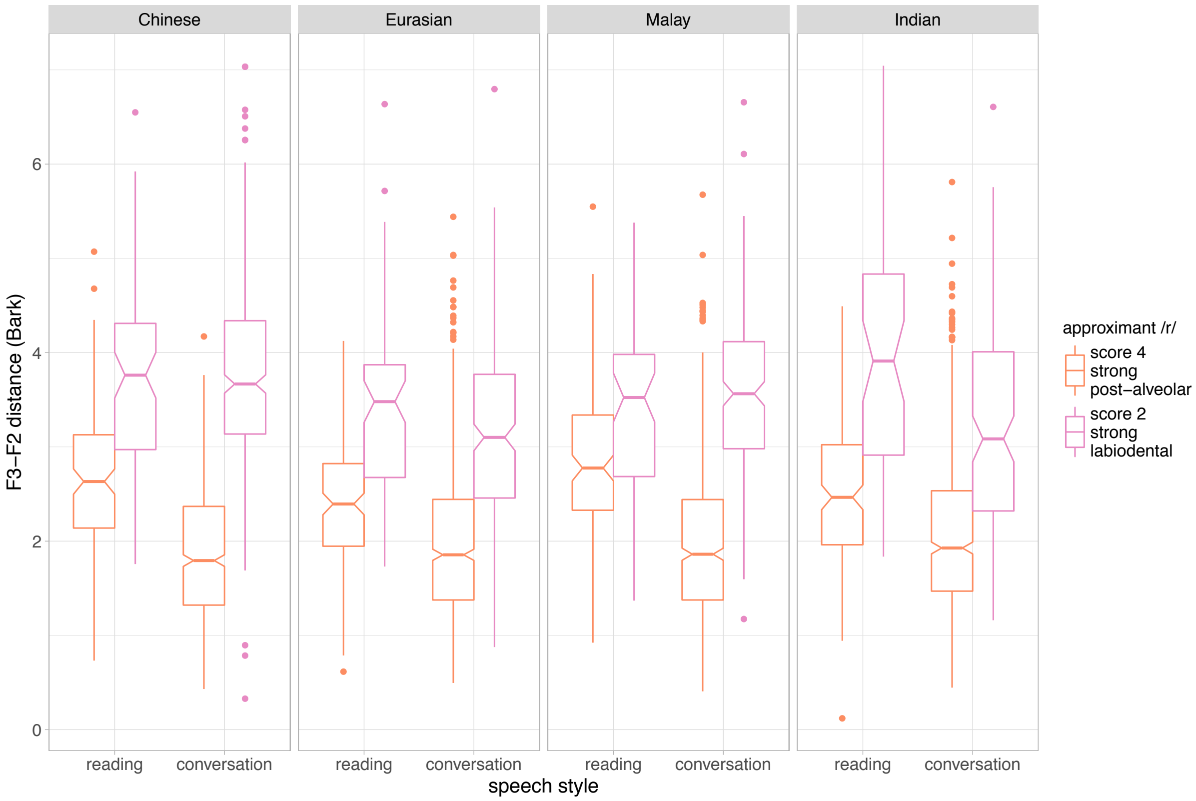

Figure 5.8: Ethnic-specific comparisons of F3-F2 distances for Scores 2 and 4 (i.e. strong labiodental approximant and strong post-alveolar approximant) in both reading and conversation.

In general, the F3-F2 distances of Scores 2 and 4 (i.e. strong labiodental approximant and strong post-alveolar approximant) for all ethnic groups appear to differ in similar ways in each speech style. This is illustrated in Figure 5.8 where, within each panel, the pair of boxes on the left represents read speech and that on the right represents conversational speech. The wider F3-F2 distances for Score 2 (i.e. strong labiodental approximant) compared to Score 4 (i.e. strong post-alveolar approximant) across all ethnic groups, as reported in Section 5.1.1, is consistent in both reading and conversation, as seen in Figure 5.5 and also indicated by the negative estimates for Score 4 (p < .001) in Table 5.4. There is, thus, strong evidence that speech style, like ethnicity, does not affect the direction of effect in the comparison of strong variants of both approximant /r/ realisations in SgE; narrower F3-F2 distance for a perceptually strong post-alveolar approximant (i.e. Score 4) and wider F3-F2 distance for a strong labiodental approximant (i.e. Score 2) is found in reading and also in conversation for all speakers regardless of ethnicity.

Table 5.4: Comparisons of F3-F2 distances for Score 4 and Score 2 (reference level) within each ethnicity in both reading and conversation, generated from the LME random slope model (/r/ score-ethnicity-speech style interaction) (values rounded off to 3 decimal places).

Reading						
	Estimate	**Standard Error**	**df**	***t* value**	**Pr(>|*t*|)**	**Significance**
Chinese						
(Intercept)	3.251	0.172	141	18.937	< 2e-16	***
Score 4	-0.947	0.097	3821	-9.764	< 2e-16	***
Eurasian						
(Intercept)	2.977	0.180	125	16.505	< 2e-16	***
Score 4	-1.005	0.098	3723	-10.311	< 2e-16	***
Malay						
(Intercept)	3.058	0.174	148	17.577	< 2e-16	***
Score 4	-0.635	0.102	3726	-6.219	< 0.0001	***
Indian						
(Intercept)	3.302	0.196	129	16.866	< 2e-16	***
Score 4	-1.245	0.109	3736	-11.448	< 2e-16	***

Conversation						
	Estimate	**Standard Error**	**df**	***t* value**	**Pr(>|*t*|)**	**Significance**
Chinese						
(Intercept)	3.572	0.149	81	23.901	< 2e-16	***
Score 4	-1.797	0.050	4038	-36.130	< 2e-16	***
Eurasian						
(Intercept)	2.992	0.163	84	18.373	< 2e-16	***
Score 4	-1.226	0.057	3667	-21.657	< 2e-16	***
Malay						
(Intercept)	3.540	0.153	88	23.160	< 2e-16	***
Score 4	-1.711	0.058	4287	-29.746	< 2e-16	***
Indian						
(Intercept)	2.876	0.178	88	16.194	< 2e-16	***
Score 4	-1.049	0.070	3990	-14.922	< 2e-16	***

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

Besides narrower F3-F2 distances, strong post-alveolar approximants (i.e. Score 4) also have overall lower F3s (see Figure 5.9) and larger F3 transitions (see Figure 5.10) than strong labiodental approximants (i.e. Score 2) across all ethnic groups and speech styles. Results here thus echo the findings of an earlier study of approximant /r/ in SgE (Kwek, 2012) where post-alveolar approximants were reported to have lower F3s and higher F3 rises (i.e. F3 transitions) than labiodental approximants.

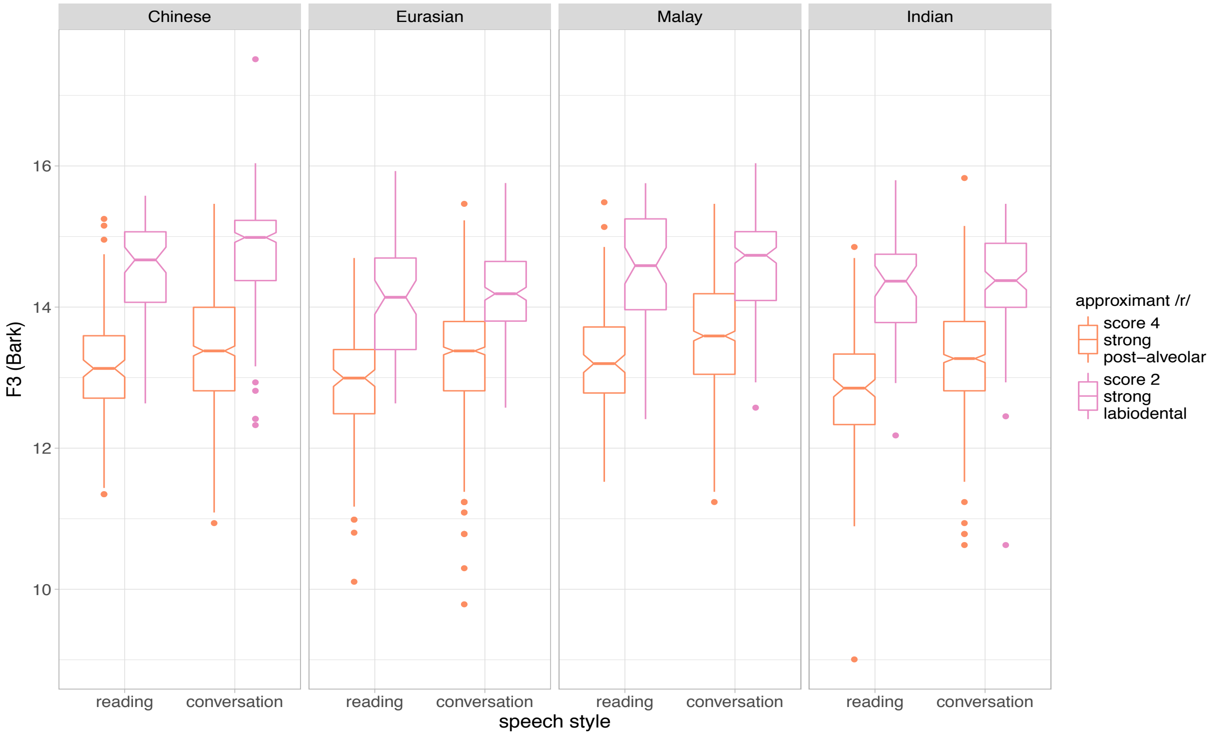

Figure 5.9: Ethnic-specific comparisons of F3 for Scores 2 and 4 (i.e. strong labiodental approximant and strong post-alveolar approximant) in both reading and conversation.

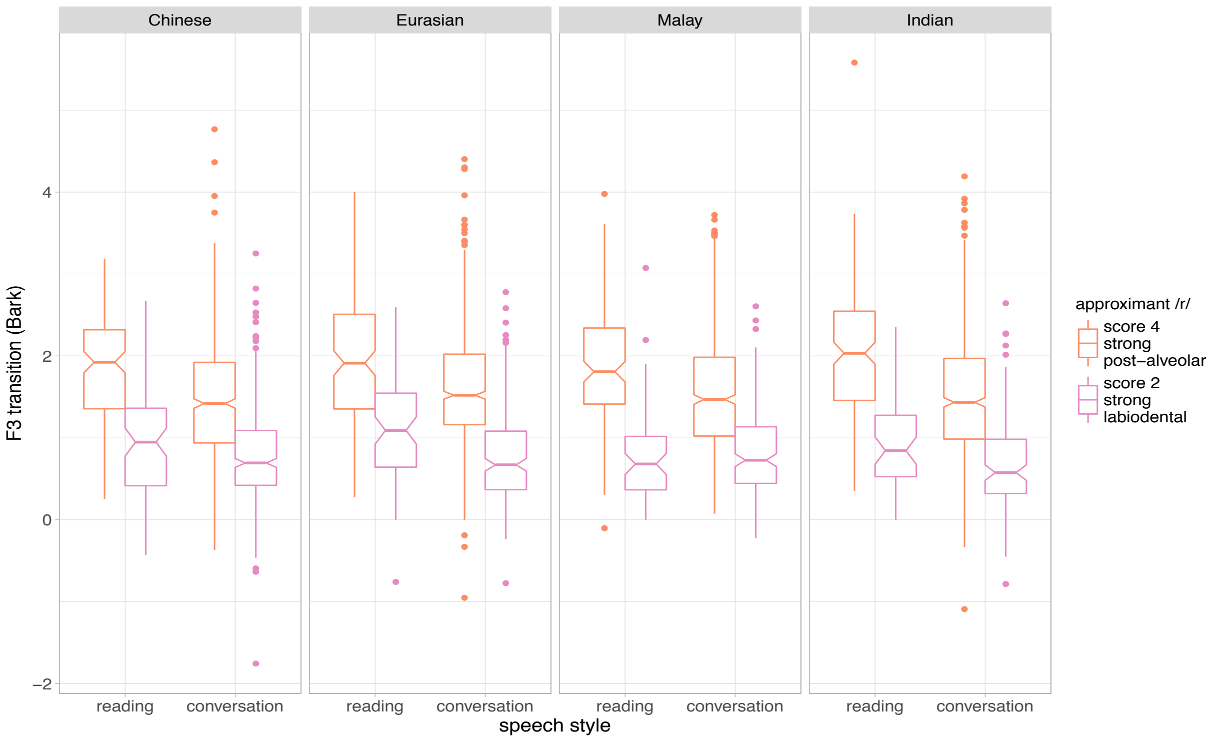

Figure 5.10: Ethnic-specific comparisons of F3 transitions for Scores 2 and 4 (i.e. strong labiodental approximant and strong post-alveolar approximant) in both reading and conversation.

While there are similarities in the direction of effects for both speech styles amongst ethnic groups when comparing F3-F2 distances of Scores 2 and 4 (i.e. strong labiodental approximant and strong post-alveolar approximant), it can be seen from Figure 5.11 that the size of effects between speech styles differs for ethnically Chinese, Malay and Indian SgE speakers. This is depicted by the differences in the steepness of slopes of blue (i.e. reading) and red (i.e. conversation) lines for these ethnic groups. Only for ethnically Eurasian SgE speakers do Scores 2 and 4 (i.e. strong labiodental approximant and strong post-alveolar approximant) differ in relatively similar magnitudes between read and conversational speech, as indicated by the almost-parallel blue and red lines.

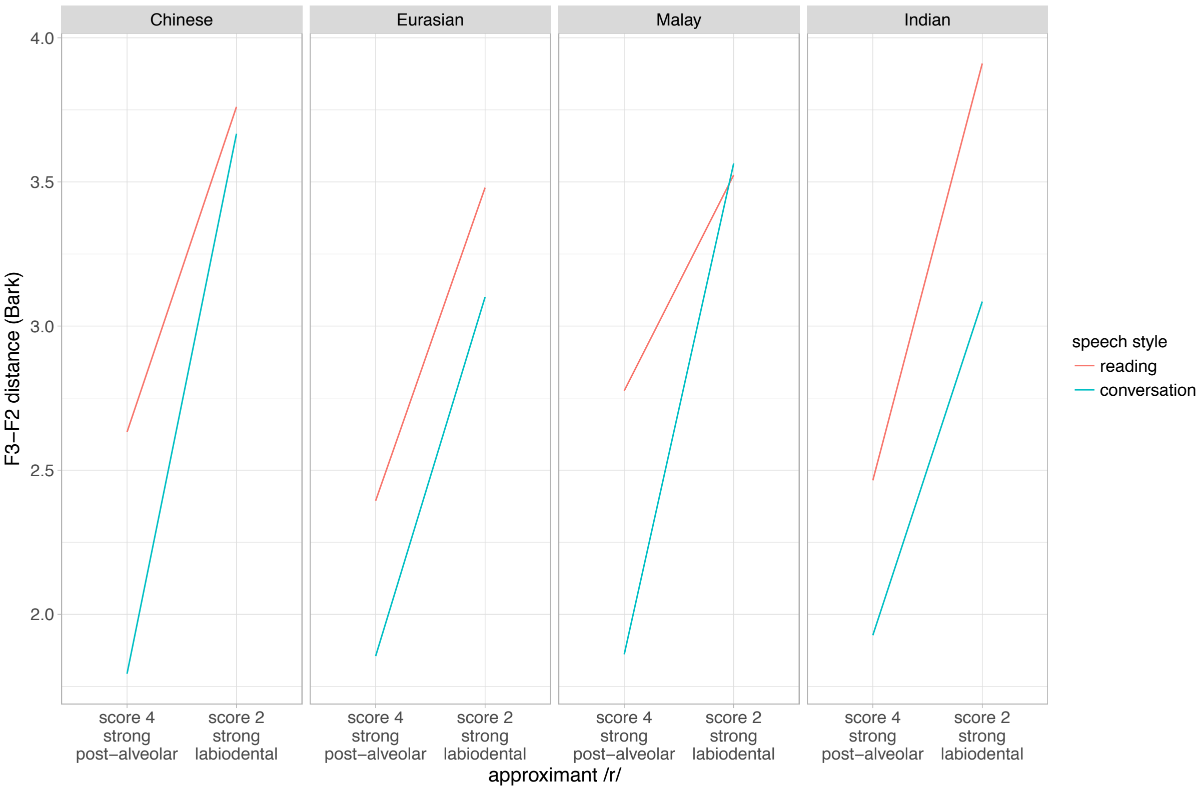

Figure 5.11: Direction and size of ethnicity and speech style effects on F3-F2 distances of Scores 2 and 4 (i.e. strong labiodental approximant and strong post-alveolar approximant) in both reading and conversation.

This further analysis thus highlights the following findings in the comparison of the clear strong realisations of both the labiodental and the post-alveolar approximant /r/:

- The direction of speech style effects on the differences between the labiodental approximant and post-alveolar approximant is the same for all speakers of SgE. For all ethnic groups and in both speech styles, the labiodental approximant always has a wider F3-F2 distance, a higher F3, and a smaller F3 transition than the post-alveolar approximant.

- The size of effects, however, differs for ethnically Chinese, Malay, and Indian SgE speakers. The difference in F3-F2 distance between both variants of approximant /r/ is relatively similar in reading as in conversation for ethnically Eurasian SgE speakers
  1) For ethnically Chinese and Malay SgE speakers, the difference between the F3-F2 distance of the labiodental approximant and the post-alveolar approximant in reading is smaller than in conversation.
  2) For ethnically Indian SgE speakers, the difference between the F3-F2 distance of the labiodental approximant and the post-alveolar approximant in reading is bigger than in conversation.
- The above differences appear to be brought about by differences within the individual scores (particularly Score 2) between speech styles.
  1) For ethnically Chinese and Malay SgE speakers, the difference between the F3-F2 distance of the labiodental approximant in reading and in conversation is very small while there is a big difference between the F3-F2 distance of the post-alveolar approximant in reading and in conversation.
  2) For ethnically Indian SgE speakers, the difference between the F3-F2 distance of the labiodental approximant in reading and in conversation is bigger than the difference between the F3-F2 distance of the post-alveolar approximant in reading and in conversation.

The possibility of differences within individual scores therefore led to the subsequent analyses, as reported in Section 5.2, which were focused on comparing ethnic and speech style differences within Score 2 (i.e. strong labiodental approximant) and Score 4 (i.e. strong post-alveolar approximant) individually in the attempt to determine the causes and implications of these observations.

5.2 Acoustic differences within variants of approximant /r/ in Singapore English

5.2.1 Score 2 – strong labiodental approximant /r/

Here, a similar LME random slope model was fitted to the data which included only non-syllable-final tokens of Score 2 (i.e. strong labiodental approximants) from both read and conversational data. The same fixed and random effects, as included in previous models, were kept. This time, only one interaction between ethnicity and speech style was included. To facilitate the analysis of F3-F2 distances of strong labiodental approximants (i.e. Score 2) amongst all four ethnic groups in both speech styles (i.e. reading and conversation), an additional multiple comparison procedure using a general linear hypothesis in a Tukey Honestly Significant Difference (Tukey HSD) test was carried out on the LME model with the *glht* function in the multcomp package (Hothorn et al., 2016). As before, all statistical analyses were done in R (R Core Team, 2016). Results obtained from the all-pair comparison of the model are presented in Table 5.5.

In conversation, the strong labiodental approximants (i.e. Score 2) produced by ethnically Chinese SgE speakers always have wider F3-F2 distances than those produced by the other ethnic groups (see Figure 5.12 and Table 5.5). However, they are only significantly different from those produced by their ethnically Eurasian and Indian counterparts ($p < .001$) and not from those produced by their ethnically Malay ones. Ethnically Malay SgE speakers also produce strong labiodental approximants (i.e. Score 2) with significantly wider F3-F2 distances compared to ethnically Eurasian and ethnically Indian SgE speakers ($p < .01$). Between ethnically Eurasian SgE speakers and ethnically Indian SgE speakers, however, although the former group appears to have strong labiodental approximants (i.e. Score 2) with wider F3-F2 distances, differences between the two groups are found to be non-significant. This finding resonates with the effect of ethnicity on the frequency occurrence of /r/ realisations in non-syllable-final positions reported in Section 4.2 for which ethnically Chinese and Malay SgE speakers are hypothesised to be leading the change in a potential /r/ 'weakening' process. Since wider F3-F2 distances in Score 2 (i.e. strong labiodental approximant) realisations suggest a stronger labiodental quality and, consequently, weaker perceived rhotic qualities, the ethnicity effects here provide further support for ethnically

Chinese and Malay SgE speakers leading the said change not only in frequency of occurrence but also in quality of the /r/ realisation.

Table 5.5: Multiple comparison of F3-F2 distances of Score 2 between ethnic groups in conversation and reading; General Linear Hypothesis on LME model (ethnicity-speech style interaction) (values rounded off to 3 decimal places), (n = 1169).

Conversation						
Focus level	**Reference level**	**Estimate**	**Standard Error**	**z value**	**Pr(>|z|)**	**Significance**
Eurasian	Chinese	-0.624	0.137	-4.557	< 0.001	***
Malay	Chinese	-0.117	0.137	-0.857	0.827	
Indian	Chinese	-0.694	0.152	-4.565	< 0.001	***
Malay	Eurasian	0.507	0.143	3.546	0.002	**
Indian	Eurasian	-0.070	0.155	-0.453	0.969	
Indian	Malay	-0.576	0.158	-3.656	0.001	**
Reading						
Focus level	**Reference level**	**Estimate**	**Standard Error**	**z value**	**Pr(>|z|)**	**Significance**
Eurasian	Chinese	-0.357	0.173	-2.067	0.164	
Malay	Chinese	-0.298	0.176	-1.692	0.328	
Indian	Chinese	-0.001	0.189	-0.003	1.000	
Malay	Eurasian	0.058	0.176	0.332	0.987	
Indian	Eurasian	0.356	0.186	1.910	0.223	
Indian	Malay	0.298	0.193	1.543	0.411	

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

No significant differences in the F3-F2 distances of strong labiodental approximants (i.e. Score 2) between ethnic groups are found in read speech data, as seen in Table 5.5. This suggests that there is more obvious ethnically-determined variation in the realisation of strong labiodental approximants in conversation than in reading. What is interesting to note here is that the ethnicity effects found in conversation (e.g. ethnically Chinese SgE speakers have wider F3-F2 distance than ethnically Malay SgE speakers) are the same for all ethnic-group comparisons in reading, with the exception of those involving the ethnically Indian SgE speakers (see Table 5.5). Ethnically Indian SgE speakers have narrower F3-F2 distances in strong labiodental approximants (i.e. Score 2) than all the other ethnic groups in conversation but wider F3-F2 distances than everyone else in reading. This thus means that they are the speakers who have the strongest labiodental qualities in reading and the weakest labiodental qualities in conversation as compared to the other speakers. They also, therefore, make the largest distinction in labiodental approximant realisation between speech styles.

Additionally, it was also found that while all other ethnic groups have wider F3-F2 distances for Score 2 (i.e. strong labiodental approximant) in reading than in conversation, speech style effect is different for ethnically Malay SgE speakers. For them, F3-F2 distances are narrower in reading than in conversation. This is indicated by the difference in direction of slope in the line graph plotted in Figure 5.13 and contributes to an earlier observation that ethnically Malay SgE speakers behave differently from other SgE speakers in the production of strong labiodental approximants (i.e. Score 2).

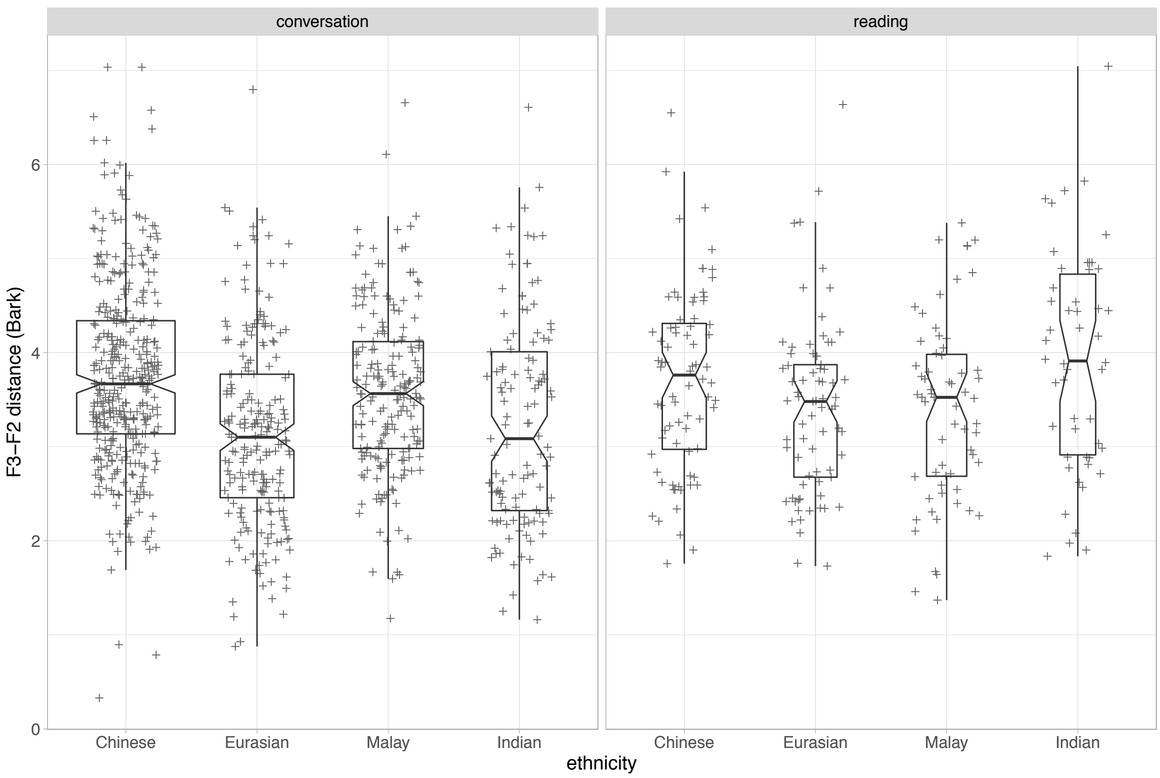

Figure 5.12: F3-F2 distances of Score 2 (i.e. strong labiodental approximant) for all ethnic groups in both conversation and reading, (n = 1169).

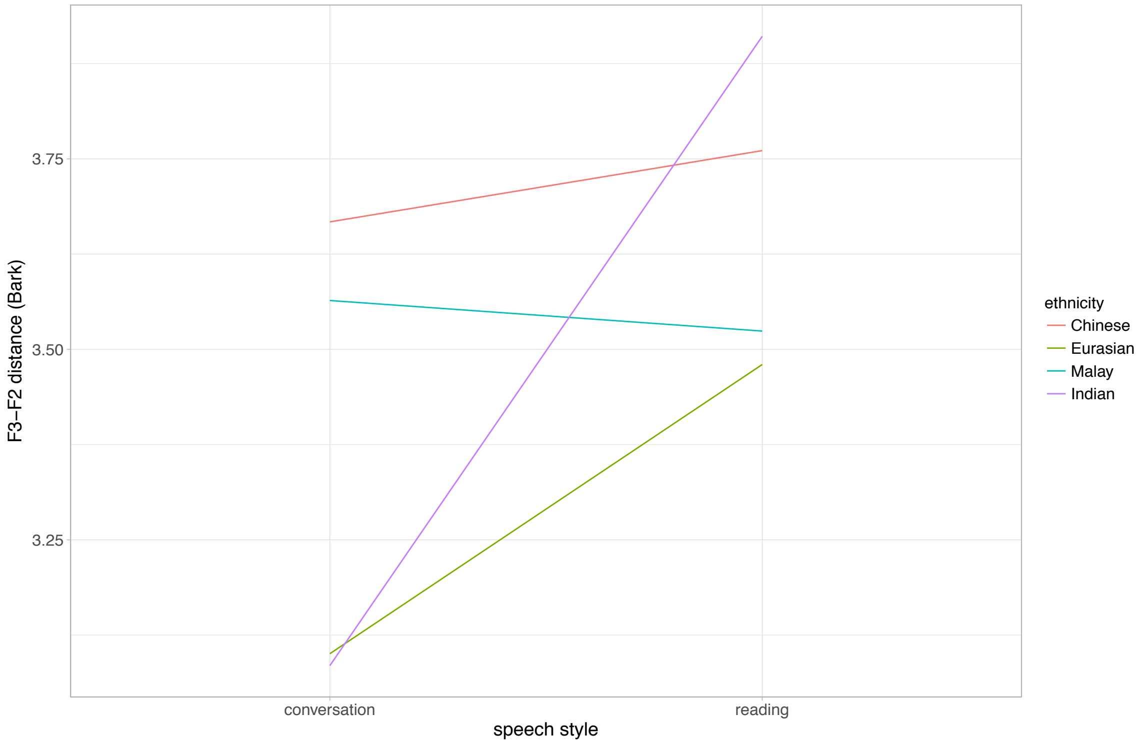

Figure 5.13: Direction and size of ethnicity and speech style effects on F3-F2 distances of Score 2 (i.e. strong labiodental approximant), (n = 1169).

In summary, therefore, the following observations can be made of the strong labiodental approximant /r/ across the speaker sample in both speech styles:

- In conversation, the strong labiodental approximant produced by ethnically Chinese and Malay SgE speakers have wider F3-F2 distances than ethnically Eurasian and Indian SgE speakers.
- In reading, there is no significant difference in F3-F2 distances of the strong labiodental approximant produced by SgE speakers of the various ethnic groups.
- Although the differences were found to be insignificant, the direction of ethnicity effect on F3-F2 distance of the strong labiodental approximant is the same in reading as it is in conversation except for ethnically Indian SgE speakers. For them, F3-F2 distance for the strong labiodental approximant is wider than that for everyone else in reading and narrower than that for everyone else in conversation.
- Ethnically Chinese, Eurasian, and Indian SgE speakers have wider F3-F2 distances for the strong labiodental approximant in reading than in conversation. Ethnically

Malay SgE speakers, however, have narrower F3-F2 distances in reading than in conversation.

5.2.2 Score 4 – strong post-alveolar approximant

The same LME analysis was carried out on non-syllable-final tokens of Score 4 from both speech styles as done for Score 2. Similarly, multiple comparison tests were then run to compare the F3-F2 distances of strong post-alveolar approximants (i.e. Score 4) between ethnic groups in both reading and conversation. As presented in Table 5.6, no significant difference was found in any of the ethnic-group comparisons in conversation, suggesting that there is no ethnicity effect on the F3-F2 distances of Score 4 when in conversational speech. This means that the strong post-alveolar approximants (i.e. Score 4) produced by all SgE speakers in conversation are acoustically similar, as illustrated in Figure 5.14.

Table 5.6: Multiple comparison of F3-F2 distances of Score 4 between ethnic groups in conversation and reading; General Linear Hypothesis on LME model (ethnicity-speech style interaction) (values rounded off to 3 decimal places), (n = 3525).

Conversation						
Focus level	**Reference level**	**Estimate**	**Standard Error**	***z* value**	**Pr(>|*z*|)**	**Significance**
Eurasian	Chinese	-0.049	0.098	-0.495	0.960	
Malay	Chinese	0.060	0.097	0.616	0.927	
Indian	Chinese	0.029	0.101	0.284	0.992	
Malay	Eurasian	0.109	0.098	1.111	0.683	
Indian	Eurasian	0.077	0.098	0.791	0.858	
Indian	Malay	-0.031	0.101	-0.311	0.990	
Reading						
Focus level	**Reference level**	**Estimate**	**Standard Error**	***z* value**	**Pr(>|*z*|)**	**Significance**
Eurasian	Chinese	-0.355	0.114	-3.118	0.010	**
Malay	Chinese	0.128	0.114	1.128	0.672	
Indian	Chinese	-0.256	0.115	-2.217	0.119	
Malay	Eurasian	0.483	0.113	4.261	<0.001	***
Indian	Eurasian	0.099	0.112	0.886	0.812	
Indian	Malay	-0.384	0.115	-3.348	0.005	**

Significance codes: '***' $p < 0.001$, '**' $p < 0.01$, '*' $p < 0.05$

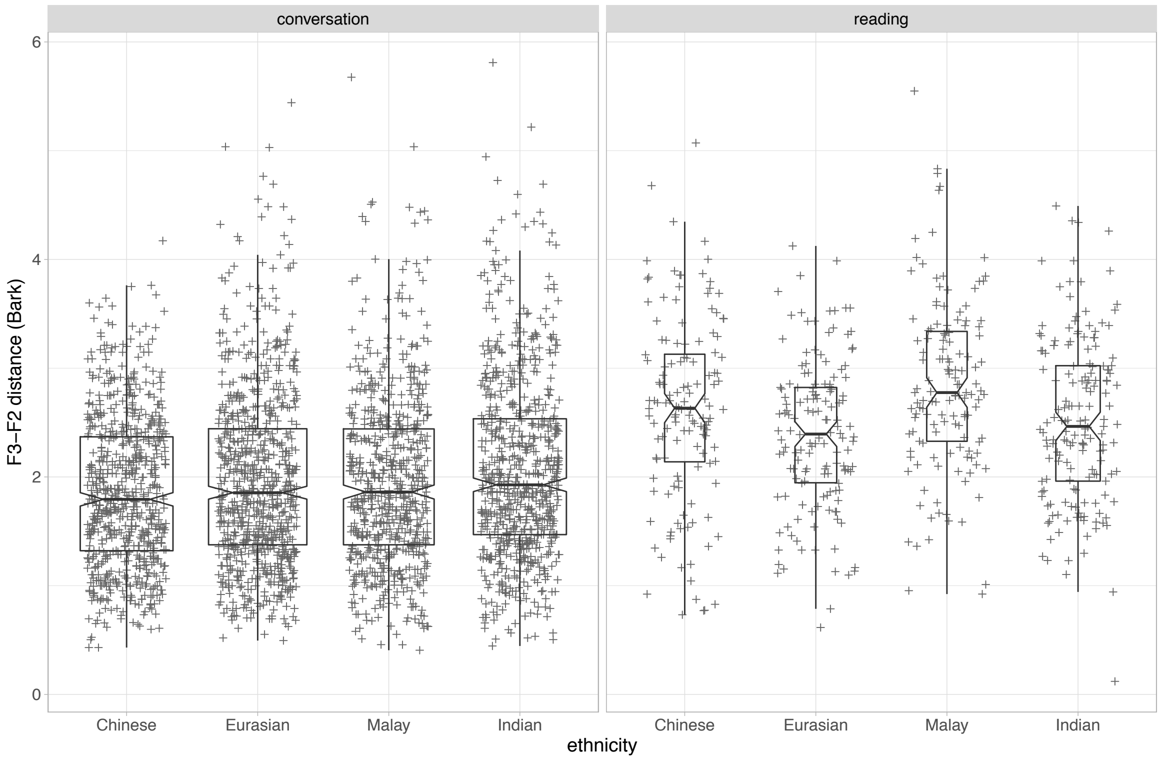

Figure 5.14: F3-F2 distances of Score 4 (i.e. strong post-alveolar approximant) for all ethnic groups in both conversation and reading, (n = 3525).

Some differences, however, can be seen for reading. F3-F2 distances of Score 4 in read speech are different between ethnically Eurasian and their ethnically Chinese ($p < .01$) and Malay ($p < .001$) counterparts, and between ethnically Indian and Malay ($p < .01$) SgE speakers (see Table 5.6 and Figure 5.14). This implies that F3-F2 distances of Score 4 amongst ethnic groups are more unalike in read speech but more alike in conversation speech, as seen clearly in Figure 5.15. This is the reverse of what was found for Score 2. There are no ethnicity effects for Score 2 in reading but differences are shown in conversation. It can also be seen that, in general, speech style effects on strong post-alveolar approximants (i.e. Score 4) of all ethnic groups are in the same direction (i.e. F3-F2 distance is wider in reading than in conversation) and are of similar sizes, as depicted by the similar steepness of slopes in Figure 5.15, unlike the strong labiodental approximant (i.e. Score 2) which had various differences as previously reported.

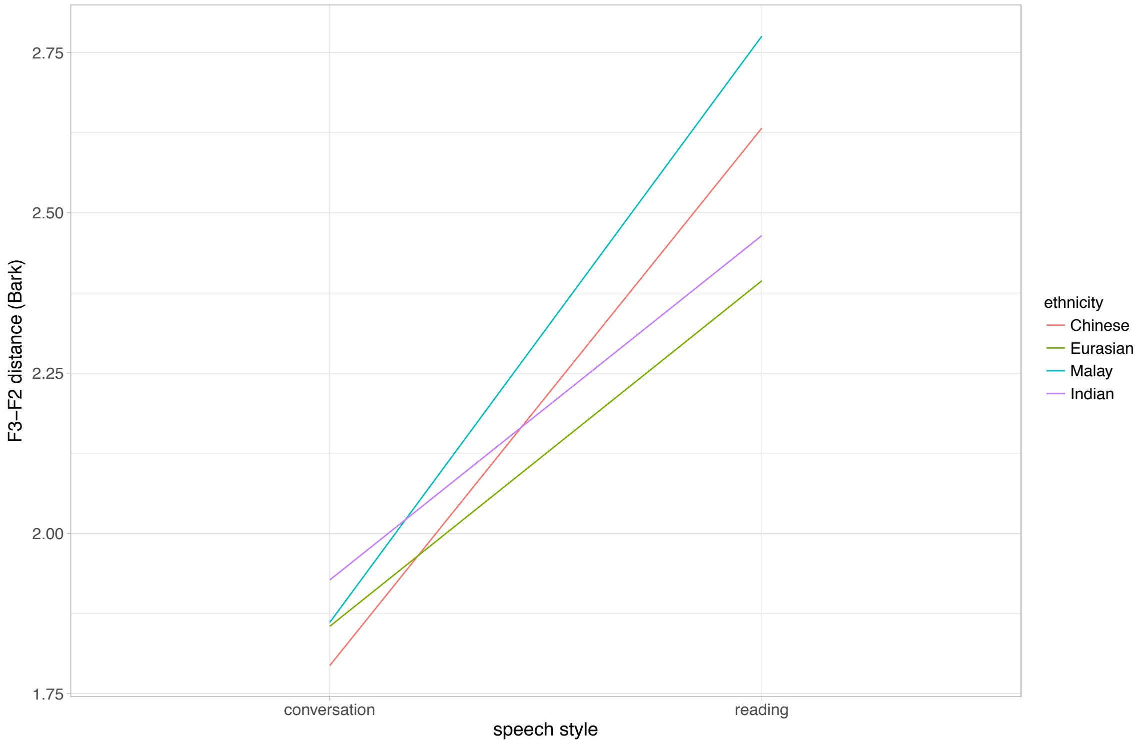

Figure 5.15: Direction and size of ethnicity and speech style effects on F3-F2 distances of Score 4 (i.e. strong post-alveolar approximant), (n = 3525).

Observations made of the strong post-alveolar approximant across the speaker sample and two speech styles showed some differences from those made of the strong labiodental approximant:

- In conversation, there is no significant difference in F3-F2 distances of the strong post-alveolar approximant produced by SgE speakers of the various ethnic groups.
- In reading, there are some significant differences. F3-F2 distance of the strong post-alveolar approximant produced by ethnically Eurasian SgE speakers is different (i.e. narrower) from those produced by ethnically Chinese and Malay SgE speakers and the F3-F2 distance of the strong post-alveolar approximant produced by ethnically Indian SgE speakers is also narrower than those produced by Malay SgE speakers.
- The direction and size of speech style effect on the F3-F2 distance of the strong post-alveolar approximant is the same for all ethnic groups.

  1) For all SgE speakers, F3-F2 distance for the strong post-alveolar approximant is wider in reading than in conversation.

2) Differences in F3-F2 distance between the strong post-alveolar approximant in reading and in conversation are relatively similar for all four ethnic groups.

5.3 Key findings of the acoustic analysis of approximant /r/ variation in Singapore English

This acoustic analysis revealed various details of /r/ variation between and within the approximant /r/ variants (i.e. weak and strong labiodental and post-alveolar approximants) which contribute to the understanding of not only the acoustics of approximant /r/ in SgE but also of the effects of non-linguistic factors on the acoustic variation. The key findings are as follows:

1) Comparing between weak and strong variants of both types of approximant /r/, more variation is seen in the acoustic measures of the labiodental approximant variants than the post-alveolar approximant variants.
   - The strong post-alveolar approximant always has lower F2 and F3, and larger F2 and F3 transitions than the weak post-alveolar approximant. F3-F2 distance is narrower for the strong variant and wider for the weak variant for male SgE speakers while there is no difference in F3-F2 distance between the two for female SgE speakers.
   - Although there are differences between female and male SgE speakers in the findings of the acoustic measures for the labiodental approximants, the resultant hypothesis is that the behaviours of F2 and F3 contribute to the perception of a clear labiodental approximant /r/ variant that is different from a /w/, and shares qualities with and yet distinct from the other approximant /r/ variants.
2) For all SgE speakers, regardless of ethnicity and speaker-sex, F3-F2 distance is wider, and F2 and F3 transitions are smaller for the strong labiodental approximant than for the strong post-alveolar approximant.
3) For all SgE speakers, regardless of ethnicity and speech styles, the labiodental approximant always has a wider F3-F2 distance, a higher F3, and a smaller F3 transition than the post-alveolar approximant.
4) Based on F3-F2 distance, it is suggested that the extent of differences between the labiodental approximant and the post-alveolar approximant in reading is similar to that in conversation for ethnically Eurasian SgE speakers.

5) Unlike for the ethnically Eurasian SgE speakers, the difference between F3-F2 distance of the labiodental approximant and the post-alveolar approximant in reading is smaller than in conversation for ethnically Chinese and Malay SgE speakers. The reverse pattern is also observed for ethnically Indian SgE speakers.
6) For ethnically Chinese and Malay SgE speakers, the labiodental approximant is acoustically more similar, in terms of F3-F2 distance, than the post-alveolar approximant between speech styles while the reverse pattern is again observed for the ethnically Indian SgE speakers.
7) In conversation, ethnically Chinese and Malay SgE speakers have wider F3-F2 distances for the strong labiodental approximant than ethnically Eurasian and Indian SgE speakers.
8) Amongst the four ethnic groups, ethnically Indian SgE speakers are found to have the widest F3-F2 distance for the labiodental approximant, hence strongest labiodental qualities, in reading and the narrowest F3-F2 distance, hence weakest labiodental qualities, in conversation. They also have the most distinction in labiodental approximant realisation between speech styles as compared to everyone else.
9) Ethnically Malay SgE speakers have a slightly narrower F3-F2 distance for the strong labiodental approximant in reading than in conversation while ethnically Chinese, Eurasian, and Indian SgE speakers have distinctly wider F3-F2 distances for the strong labiodental approximant in reading than in conversation.
10) The strong post-alveolar approximants produced by SgE speakers of different ethnic groups are acoustically similar, in terms of F3-F2 distance, when in conversational speech. In read speech, however, there are some significant differences between SgE speakers from different ethnic groups.
11) The fact that direction and size of speech style effect on the F3-F2 distance of the strong post-alveolar approximant is the same for all ethnic groups could be a representation of the stability of the post-alveolar approximant as a standard variant that has been typically ‘taught’ and used, as compared to the emergent labiodental approximant which is in the process of development and thus more naturally attracting of variation. What is surprising here, however, is that strong post-alveolar approximants have weaker rhotic qualities, represented by wider F3-F2 distances, in reading than in conversation. This finding is unexpected and a possible reason for this remains uncertain.

This chapter has highlighted the similarities and differences between F3-F2 distances of Scores 1 – 4 on the perceptual strength index used in the auditory analysis, with the aim of providing validation for the gradient nature of approximant /r/ in SgE and the finer categorisation of perceptually strong and weak variants. It has established that there are indeed acoustic differences between the strong variants of both approximant realisations (i.e. Score 2 – strong labiodental and Score 4 – strong post-alveolar), thus qualifying their distinction in the auditory analysis. Some inferences made from the effects of non-linguistic factors on the acoustic realisations of approximant /r/ found here align, to a certain extent, with those made from the findings of the auditory analysis (e.g. ethnicity-conditioned variation), and will contribute to a discussion of the sociophonetics of /r/ variation in SgE as presented in the next chapter.

Chapter Six

Discussion and Conclusion

Bringing together findings of both auditory and acoustic analyses, this chapter provides a description of /r/ variation and also a discussion of the sociophonetics of /r/ sounds in Singapore English. It returns to the research questions posed in Chapter One and also the key predictions in Chapter Two in doing so. Potential areas for further research are also proposed before final conclusions reiterating the contributions of this study are made.

The research questions of this study are revisited, providing the basis of this chapter.

1) What are the variants of /r/ present in Singapore English?
2) How do these /r/ variants in Singapore English differ in phonotactics and acoustic features?
3) To what extent do linguistic factors (e.g. phonological position, word form, following context) affect the realisations of /r/ in Singapore English?
4) What is the role of non-linguistic factors (e.g. speech style, speaker sex, ethnicity, age) in determining /r/ variation in Singapore English?

6.1 Variants of /r/ in Singapore English: variation in acoustic correlates and phonotactics

This study has shown that alongside the most common and most expected /r/ variant, the post-alveolar approximant [ɹ], a labial /r/ - the labiodental approximant [ʋ], and the tap [ɾ]/trill [r] are variants of /r/ also found in SgE. This finding supports earlier studies of /r/ in SgE in which the emerging presence of the labiodental approximant [ʋ] in young ethnically Chinese SgE speakers (i.e. Deterding, 2007; Kwek, 2005, 2012) and the characteristic tap [ɾ]/trill [r] in Peranakan SgE speakers (i.e. Lim, 2010) were reported. These variants of /r/ found to be present in SgE also reflect those in BrE (e.g. Foulkes & Docherty, 2000), a variety which is historically connected to the development of SgE as described in Chapter One. More particularly, this study provides stronger evidence for the wider occurrence of these /r/

variants across different speaker-profile groups within SgE, lending support to a systematic account of /r/ variation in the variety.

6.1.1 The gradient nature of /r/

Speakers of this study were all found to have a range of /r/ variants and realisations, with some realisations not as distinctively auditorily categorisable as others. It was especially common for both approximant /r/ variants to have clear strong realisations as well as perceptually weaker ones. The perceptual strength index, which is a six-point ordered nominal scale adapted from earlier studies of /r/ in ScE and BrE (e.g. Foulkes & Docherty, 2000; Lawson, Scobbie, & Stuart-Smith, 2011), proved to be useful in accounting for this gradient nature of SgE /r/ (full details of the index were presented in Section 3.3). It enabled the inclusion of all perceptually clear observations of /r/ in the analysis of linguistic and non-linguistic effects on /r/ variation through the delineation of both perceptually strong (i.e. Scores 2 and 4) and weak realisations (i.e. Score 1 and 3) of approximant /r/ in SgE. Thus, reiterating that it is more realistic to expect a range of intermediate and/or incremental variants in between two variants instead of potentially erroneously assuming all tokens fit categorically into the extremes. Results of this analysis will be discussed later in parts of Sections 6.2 and 6.3.

Findings from the acoustic analysis validated the auditorily perceived distinctions between the two approximant /r/ variants (i.e. labiodental and post-alveolar approximants) and also the further perceptual categories of weak and strong realisations within each of them (i.e. weak and strong labiodental approximants – Scores 1 and 2, weak and strong post-alveolar approximants – Scores 3 and 4) as delineated in the perceptual strength index. Between the post-alveolar approximant realisations, the strong post-alveolar approximant (i.e. Score 4) was found to always have a lower F2 and F3, and larger F2 and F3 transitions than the weak post-alveolar approximant (i.e. Score 3). F3-F2 distance, however, was affected by speaker sex and not always found to be a reliable acoustic cue for the difference in perceptual strength between the post-alveolar approximant realisations. While F3-F2 distance was found to be narrower for the strong variant (i.e. Score 4), and wider for the weak variant (i.e. Score 3) for male SgE speakers, there was no difference in F3-F2 distance between the two for female SgE speakers. For the labiodental approximants (i.e. Scores 1 and 2), there is more acoustic variation determined by speaker sex. However, further analyses of the behaviours of F2 and F3 showed that these, for both female and male SgE speakers, contribute to the perception of a strong labiodental approximant /r/ (i.e. Score 2) that is different from a /w/, and shares qualities with and yet distinct from the other approximant /r/ variants (i.e. Scores 1, 3, 4). This shows that although there is variation due to the effects of speaker sex, it is undeniable that there are differences not only between the two approximant /r/ variants but also between weak and strong realisations of each. Thus providing evidence for the validity in the auditory rating of /r/ tokens according to the perceptual strength index.

In the subsequent sub-sections of Section 6.1, the description of /r/ variants in SgE will be based on observations of /r/ that are perceptually clear and also have strong acoustic evidence (i.e. Score 2 – strong labiodental approximant [ʋ], Score 4 – strong post-alveolar approximant [ɹ], and Score 5 – tap [ɾ]/trill [r]) in order to allow for clear descriptions and comparisons. Spectrographic evidence is also presented in this discussion for the illustration of acoustic and phonotactic features.

6.1.2 Approximant /r/: post-alveolar approximant [ɹ] and labiodental approximant [ʋ]

6.1.2.1 Acoustic correlates and phonotactic features

This study found two perceptually and acoustically distinct approximant /r/ variants in SgE - the post-alveolar approximant [ɹ] and the labiodental approximant [ʋ]. Within each approximant /r/ variant, a weak and a strong realisation are also perceptually identifiable and are represented in the perceptual strength index as separate categories (i.e. scores). While strong acoustic evidence was found for the distinction of a weak post-alveolar approximant (i.e. Score 3), there appeared to be too small a sample size in the acoustic data to make strong conclusions for a weak labiodental approximant (i.e. Score 1) realisation. Therefore, these weak realisations are excluded from the discussion here. However, the perceptual distinction between the two strong approximant /r/ variants in SgE, as represented in the categories of

Scores 4 and 2 in the perceptual strength index, is supported by the significant acoustic differences found between them in the acoustic measure of F3-F2 distance as reported in Section 5.1.1. Differences are also seen in the measures of F3, F2 transition, and F3 transition when the averages are calculated. These are presented in Table 6.1. While the acoustic measures were calculated separately for male and female SgE speakers, it can be seen that both groups had similar differences between their approximant /r/ variants.

Table 6.1: Averaged acoustic measurements (rounded off to the nearest 3 decimal places) of Score 4 - post-alveolar approximant [ɹ] and Score 2 - labiodental approximant [ʋ] for both female and male SgE speakers, (*n* = 4925).

	Female		**Male**	
Measurements (Bark)	**Score 4**	**Score 2**	**Score 4**	**Score 2**
F3-F2 distance	1.931	3.529	2.395	3.497
F2 transition	1.184	2.287	1.230	1.848
F3 transition	1.603	0.846	1.592	0.760
F2	11.615	11.135	10.421	10.283
F3	13.546	14.665	12.816	13.781

Consistent with previous findings (Kwek, 2012), results of this study's acoustic investigation indicate that while the post-alveolar approximant [ɹ] is signalled by a lowered F3, the labiodental approximant [ʋ] characteristically lacks an F3 lowering. These features are complemented by observably steep transitions of both F2 and F3 from the post-alveolar approximant [ɹ] to its following vowel but only of F2 from the labiodental approximant [ʋ] to its following vowel. F3 transition of the latter is typically notably flatter. This reflects the findings of earlier studies on the labiodental approximant [ʋ] in SgE (Kwek, 2012) as well as those of varieties of BrE for which the labiodental approximant [ʋ] is a prevalent /r/ variant (Foulkes & Docherty, 2000). Another observable acoustic correlate of a perceptually distinct post-alveolar approximant [ɹ] that has been stated in descriptions of approximant /r/

articulations (e.g. Delattre & Freeman, 1968; Ladefoged, 2003; Lawson, Scobbie, & Stuart-Smith, 2013) but not previously considered in studies of /r/ in SgE, is the close proximity of F2 and F3 (i.e. F3-F2 distance). Relatedly, that of a perceptually distinct labiodental approximant [ʋ] is a markedly wider F3-F2 distance. The acoustic analysis shows that F3-F2 distance of the post-alveolar approximant [ɹ] in SgE is indeed narrower than that of the labiodental approximant [ʋ]. This is seen both in Table 6.1 and in Section 5.1.2 which show that this difference is categorical for SgE speakers, regardless of ethnicity, speech style and speaker sex. The results of this study thus suggest that F3-F2 distance is useful in differentiating between the post-alveolar approximant [ɹ] and the labiodental approximant [ʋ] in SgE, while the acoustic measures of F3, and F2 and F3 transitions give more information on the articulatory strategies used to achieve the differences between the approximant /r/ variants. Examples of the acoustic differences described will be pointed out in the next few spectrograms as phonotactic variations of both approximant /r/ variants are presented.

These approximant /r/ variants in SgE not only have perceptual and acoustic distinctions but also some phonotactic variation. The post-alveolar approximant [ɹ] and the labiodental approximant [ʋ] are found in many of the same non-syllable-final phonological positions in SgE. One such phonological position is that of syllable-initial word boundaries as shown in Figures 6.1 – 6.4. Acoustic differences between the two approximant /r/ variants can be seen. The post-alveolar approximant [ɹ] in Figure 6.1 has a lower F3 and a narrower F3-F2 distance as compared to the labiodental approximant [ʋ] in Figure 6.2. The same differences are observable in Figures 6.3 and 6.4 as well.

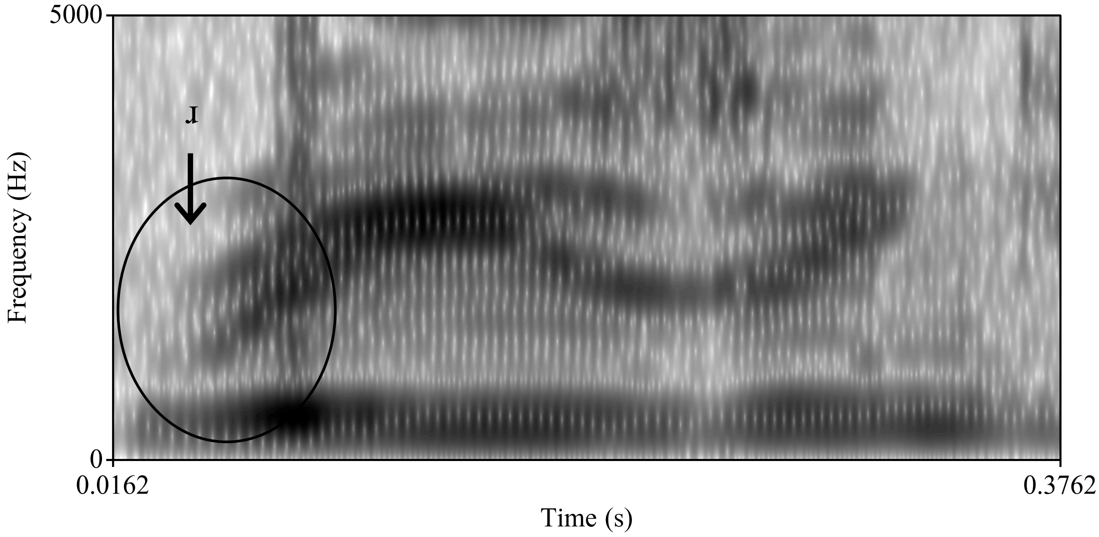

Figure 6.1: Realisation of the post-alveolar approximant [ɹ] in a syllable-initial word-boundary position - ‘raising’ (Speaker mf7, read speech)

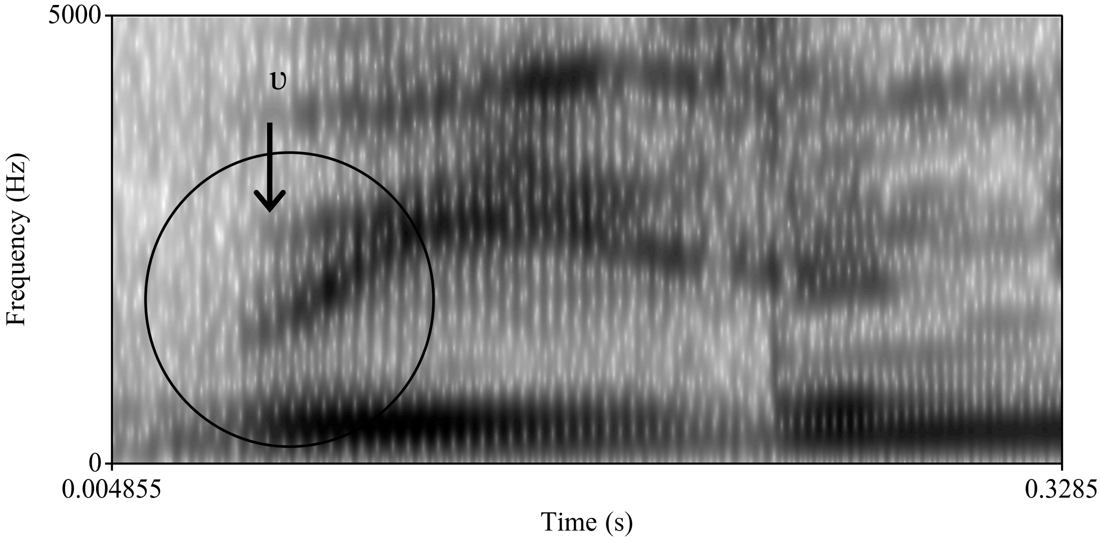

Figure 6.2: Realisation of the labiodental approximant [ʋ] in a syllable-initial word-boundary position – ‘raising’ (Speaker ef7, read speech)

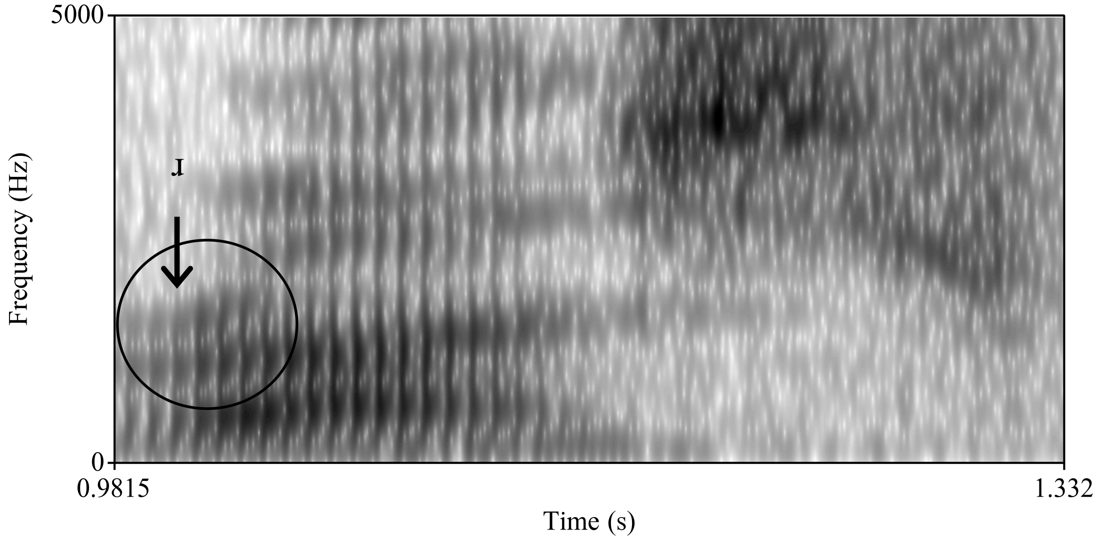

Figure 6.3: Realisation of the post-alveolar approximant [ɹ] in a syllable-initial word-boundary position – ‘rushed’ (Speaker em1, read speech)

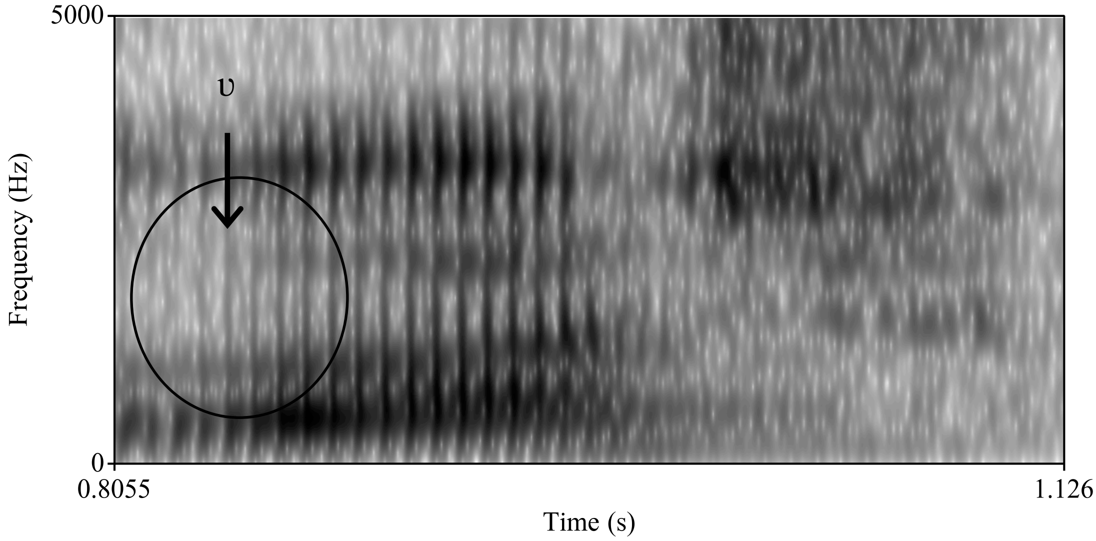

Figure 6.4: Realisation of the labiodental approximant [ʋ] in a syllable-initial word-boundary position – ‘rushed’ (Speaker mm4, read speech)

Alongside occurrences at syllable-initial word boundaries, both approximant /r/ variants also occur in all other syllable-initial positions in SgE – word-internally (see Figures 6.5 and 6.6), and in consonant clusters both at word boundaries (see Figures 6.7 and 6.8) and word-internally (see Figures 6.9 and 6.10). In these figures, it can be seen that the F3 transitions of the post-alveolar approximant [ɹ] realisations are always wider than those of the labiodental approximant [ʋ] realisations.

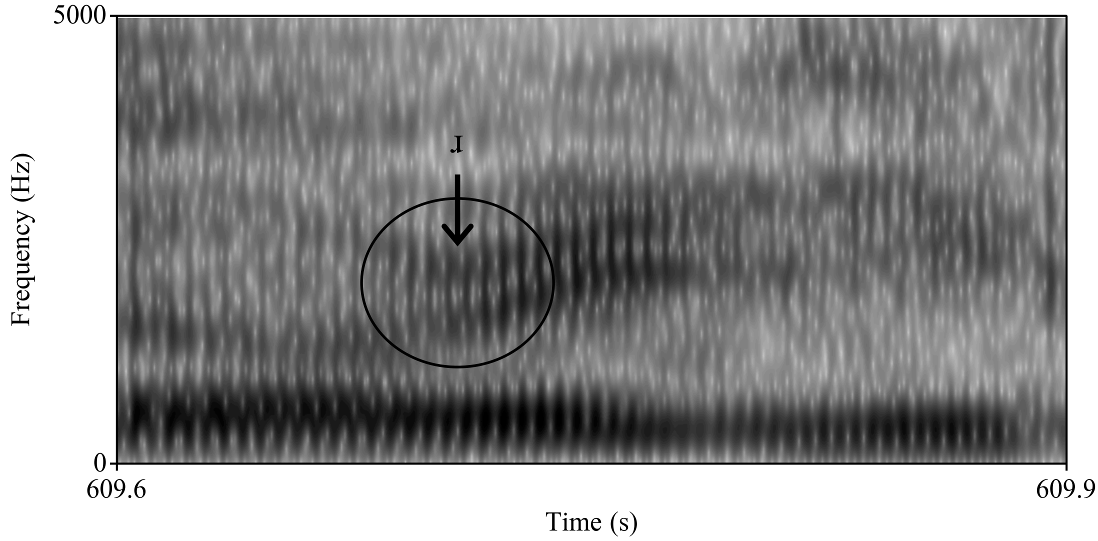

Figure 6.5: Realisation of the post-alveolar approximant [ɹ] in a syllable-initial word-internal position - 'already' (Speaker ef3, conversational speech)

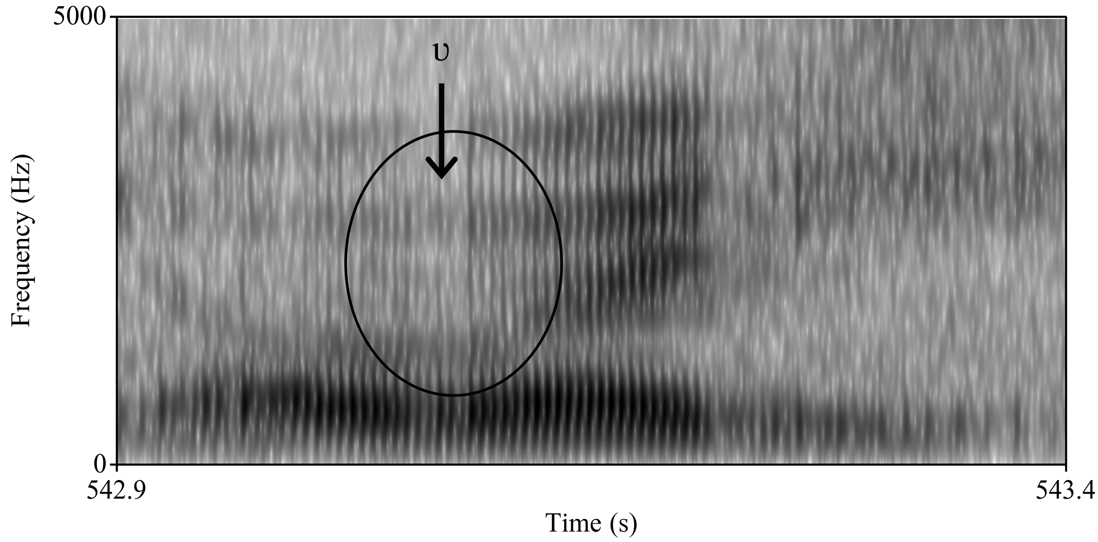

Figure 6.6: Realisation of the labiodental approximant [ʋ] in a syllable-initial word-internal position – 'already' (Speaker cf5, conversational speech)

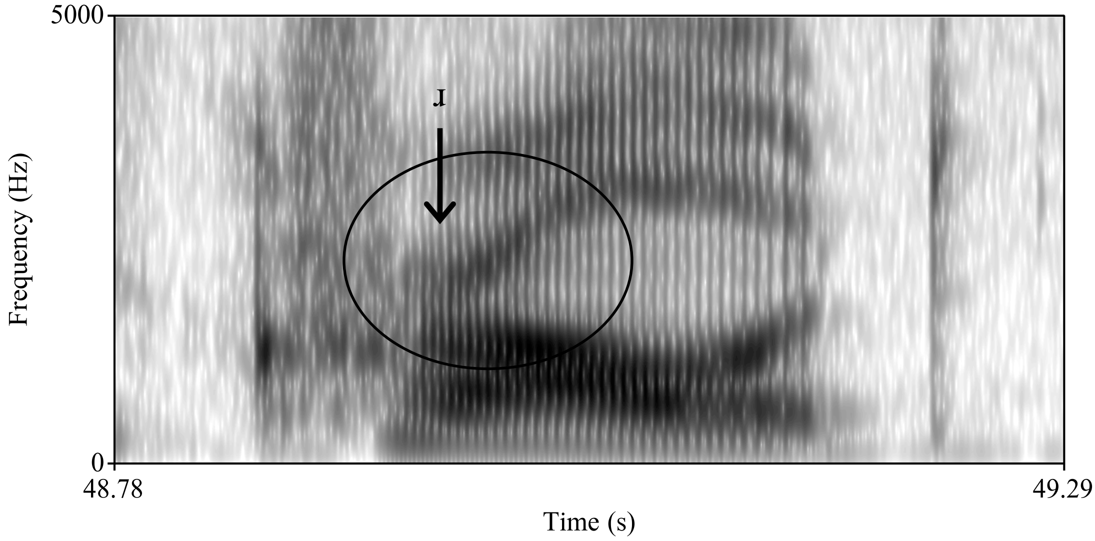

Figure 6.7: Realisation of the post-alveolar approximant [ɹ] in a syllable-initial consonant cluster (word-boundary) – ‘crowd’ (Speaker cf20, read speech)

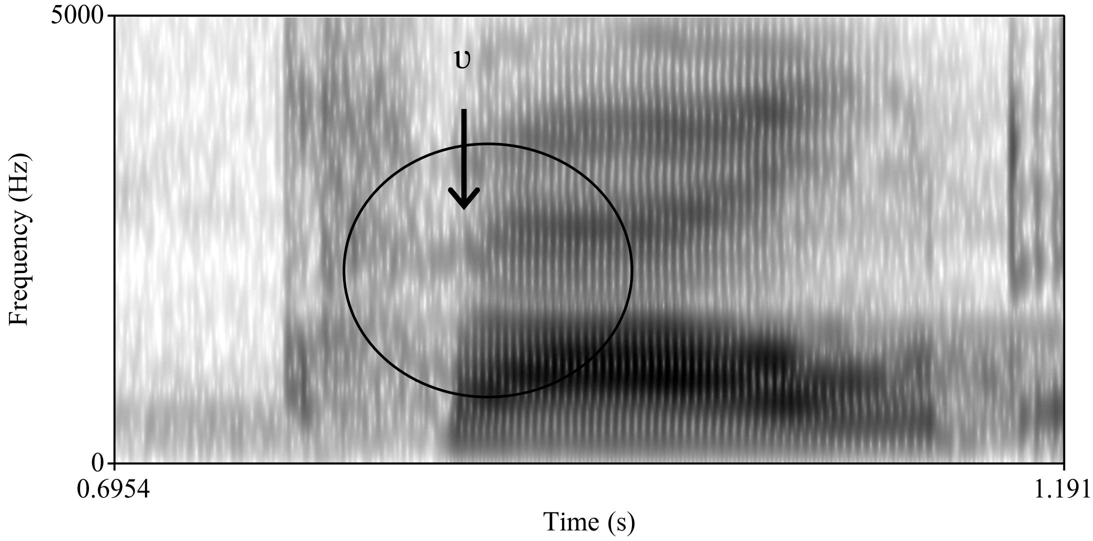

Figure 6.8: Realisation of the labiodental approximant [ʋ] in a syllable-initial consonant cluster (word-boundary) – ‘crowd’ (Speaker if1, read speech)

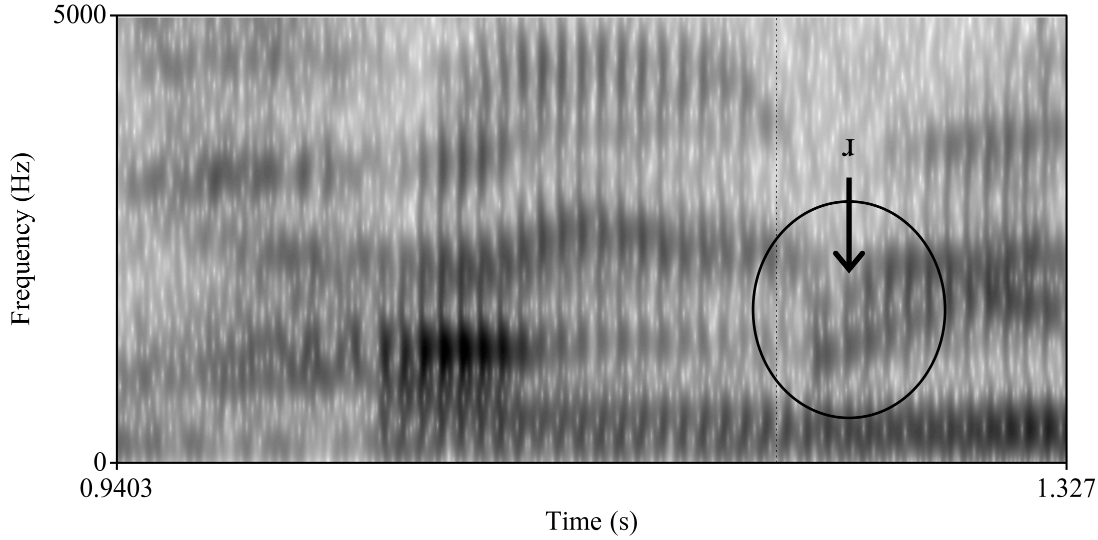

Figure 6.9: Realisation of the post-alveolar approximant [ɹ] in a syllable-initial consonant cluster (word-internal) – ‘hungry’ (Speaker im2, read speech)

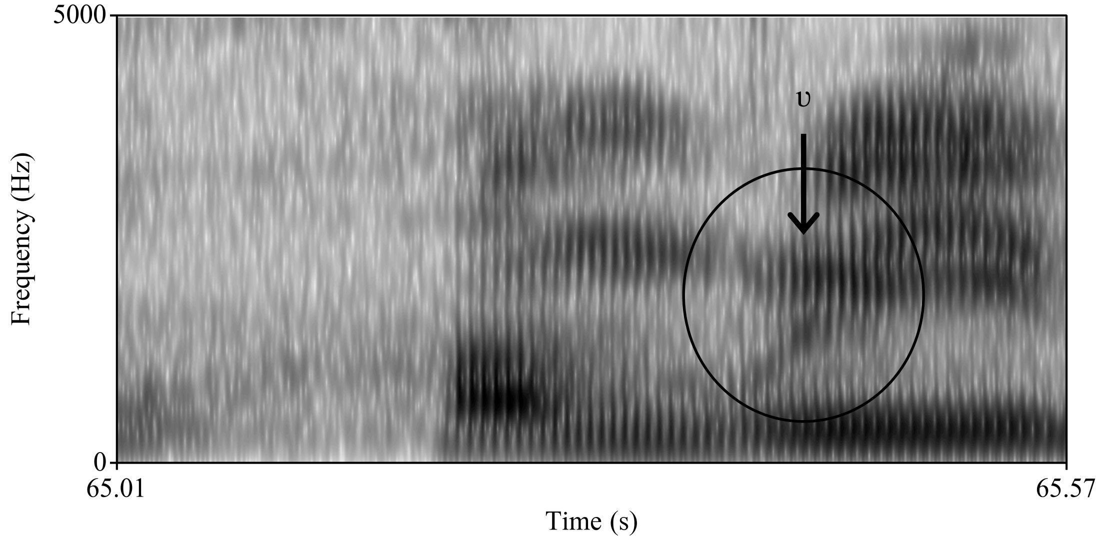

Figure 6.10: Realisation of the labiodental approximant [ʋ] in a syllable-initial consonant cluster (word-internal) – ‘hungry’ (Speaker im5, read speech)

In SgE, both approximant /r/ variants also occur in intervocalic positions, in both morpheme-internal (Figures 6.11 and 6.12) and morpheme-boundary environments (Figures 6.13 and 6.14).

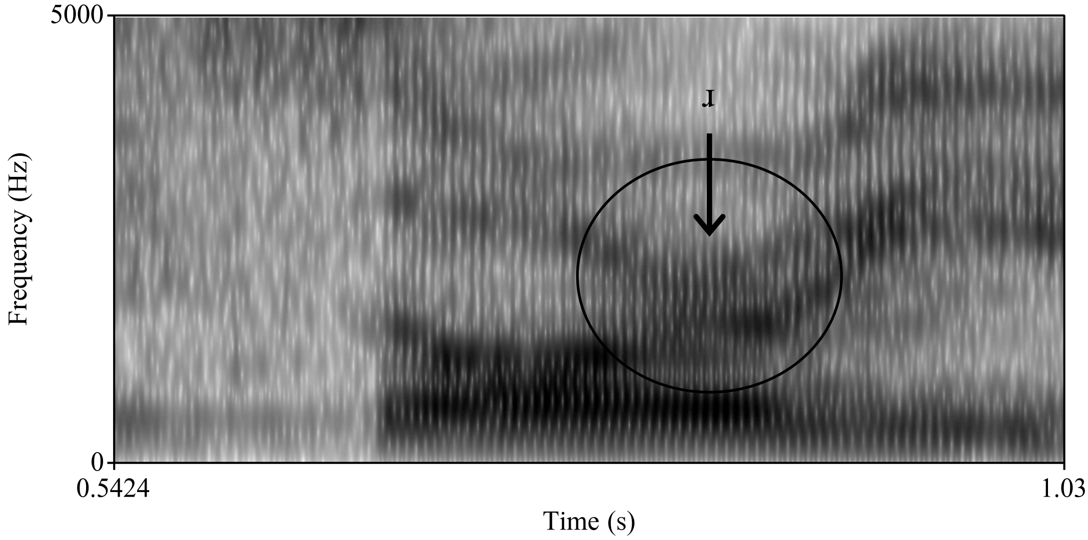

Figure 6.11: Realisation of the post-alveolar approximant [ɹ] in an intervocalic (morpheme-internal) position – ‘sorry’ (Speaker cf17, read speech)

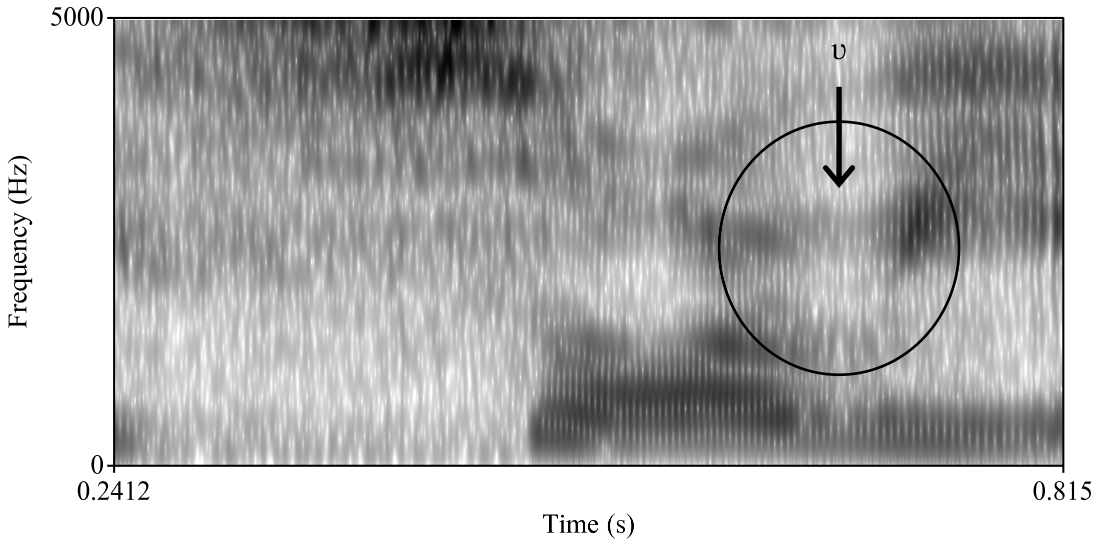

Figure 6.12: Realisation of the labiodental approximant [ʋ] in an intervocalic (morpheme-internal) position – ‘sorry’ (Speaker cf2, read speech)

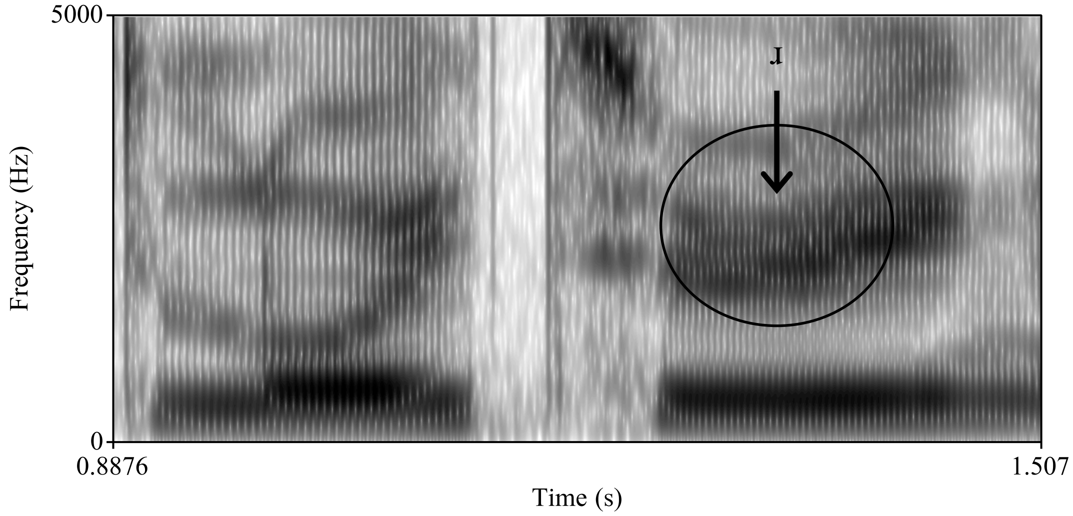

Figure 6.13: Realisation of the post-alveolar approximant [ɹ] in an intervocalic (morpheme-boundary) position – ‘loitering’ (Speaker ef4, read speech)

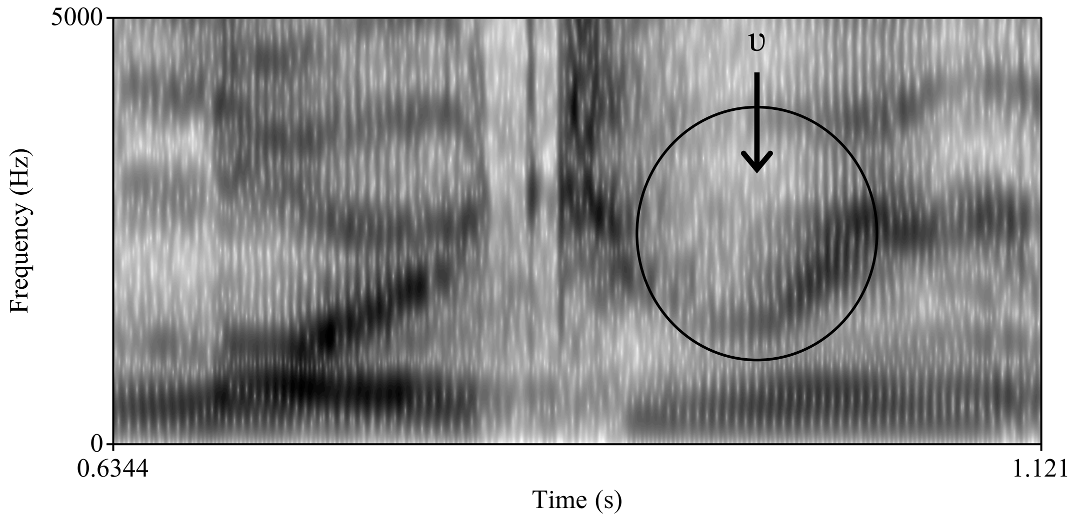

Figure 6.14: Realisation of the labiodental approximant [ʋ] in an intervocalic (morpheme-boundary) position – ‘loitering’ (Speaker ef8, read speech)

However, while the labiodental approximant [ʋ] is realised in the same syllable-initial and intervocalic positions as the post-alveolar approximant [ɹ], there appear to be constraints on the labiodental approximant [ʋ] realisations in syllable-final positions. Although SgE is traditionally described as a non-rhotic accent in which syllable-final /r/ is not realised (Trudgill & Hannah, 1994), there have been studies that report the presence of non-prevocalic /r/ in SgE (e.g. Poedjosoedarmo, 2000). This study gives evidence that this null realisation is not categorical, however, revealing a restriction on the /r/ variant that occurs syllable-finally. When a syllable-final /r/ is realised in SgE, it is usually the post-alveolar approximant [ɹ] and almost never the labiodental approximant [ʋ]. The negligible 0.5% of syllable-final /r/ observations which were labiodental approximant [ʋ] realisations, as reported in Section 4.2 (see Figure 4.4), were found to occur solely in syllable-final prevocalic positions (i.e. linking /r/); an example is shown in Figure 6.15. The low frequency of occurrence and the fact that there are no meaningful patterns of linguistic and/or non-linguistic effects observed together suggest that for SgE speakers, notwithstanding idiosyncratic occurrences, the labiodental approximant [ʋ] generally only occurs non-syllable-finally. The same acoustic differences, however, is seen between the two approximant /r/ variants when they do occur syllable-finally. In syllable-final prevocalic (word boundary) position, like in the non-syllable-final positions, the labiodental approximant [ʋ] in Figure 6.15 is also seen with relatively lower F2, higher F3, wider F3-F2 distance and flatter F3 transitions as compared to the post-alveolar approximant [ɹ] in Figure 6.16.

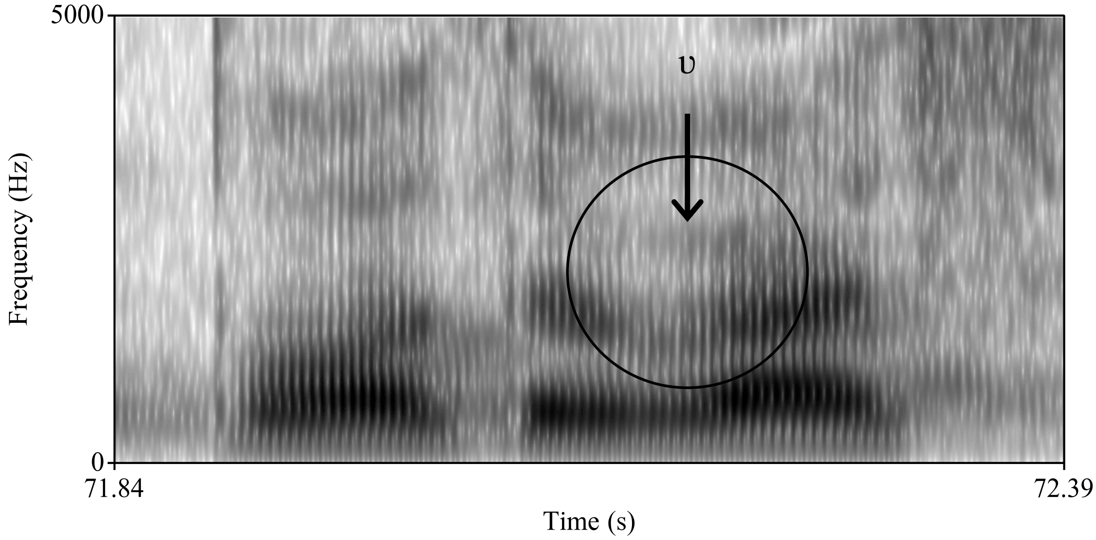

Figure 6.15: Realisation of the labiodental approximant [ʋ] in a syllable-final prevocalic (word boundary) position (i.e. linking /r/) – ‘bother us’ (Speaker cf1, read speech)

In the other syllable-final positions, syllable-final non-prevocalic positions (see Figure 6.16) and syllable-final consonant clusters (see Figure 6.17), the post-alveolar approximant [ɹ] is also the only variant that occurs. This is evidenced by the extremely low predicted probabilities of other /r/ variants (reported in Section 4.5). The /r/-sandhi phenomenon of intrusive /r/, on the rare occasion it occurs, is also realised at word boundaries as a post-alveolar approximant [ɹ] (see Figure 6.18). No instances of word-internal intrusive /r/ (e.g. 'draw(r)ing') were found in this study's analysis of SgE. It can then be concluded that SgE is a 'mostly non-rhotic' accent as Trudgill and Hannah (1994) states but, contrary to their description, linking /r/ and intrusive /r/ do occur in this variety. It is therefore probably more fitting to think of SgE as an accent that fits into Systems B or C of Harris's (1994) four systems of consonantal /r/ distribution which were reviewed in Section 2.3. To recapitulate briefly, System B is a system for accents which are non-rhotic but with linking /r/ while System C is a system for non-rhotic accents in which intrusive /r/ exists. This, however, would require a deeper phonological study of /r/ in SgE which is beyond the aims of the current study. Also, while it would be an interesting exploration, trying to fit a variety like SgE, due to its innate multifaceted character, into such fixed systems might just not be most practical.

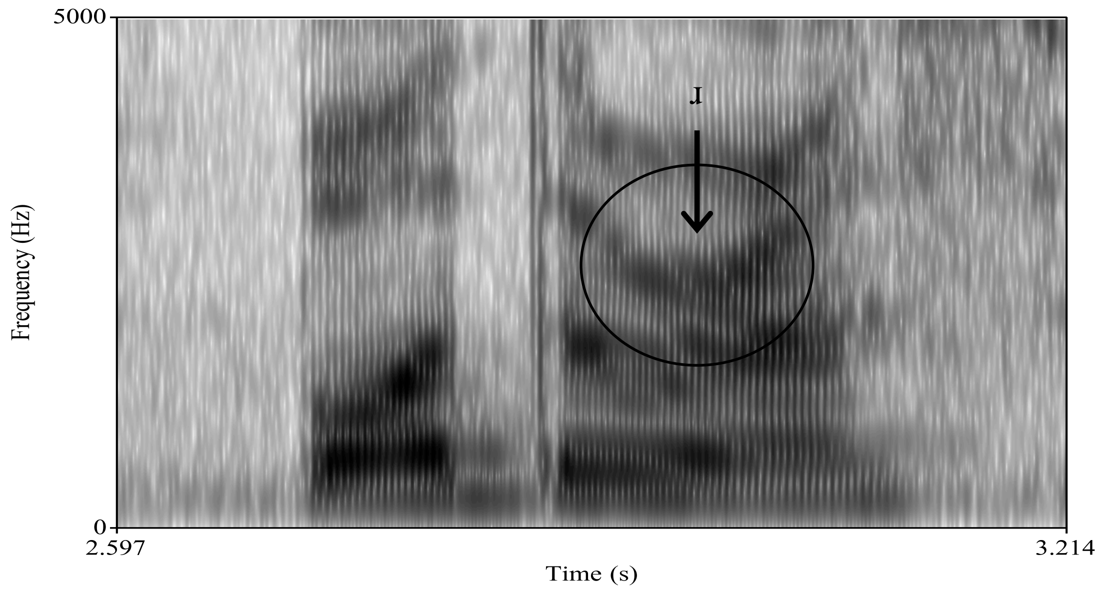

Figure 6.16: Realisation of the post-alveolar approximant [ɹ] in a syllable-final prevocalic (word boundary) position (i.e. linking /r/) – 'bother us' (Speaker mf6, read speech)

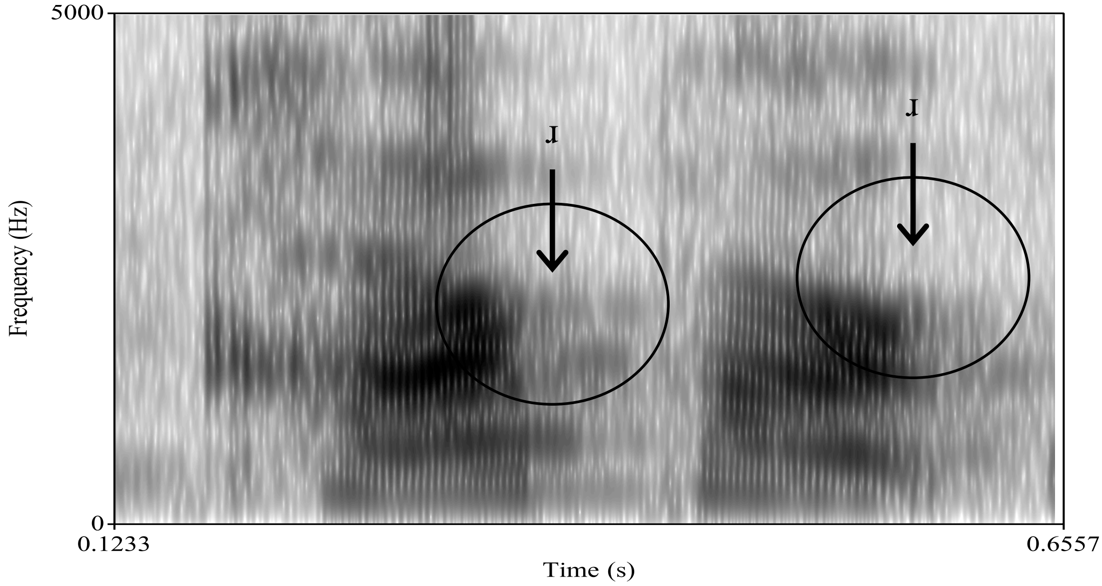

Figure 6.17: Realisation of the post-alveolar approximant [ɹ] in a syllable-final non-prevocalic position and a syllable-final consonant cluster – 'car park' (Speaker mf7, read speech)

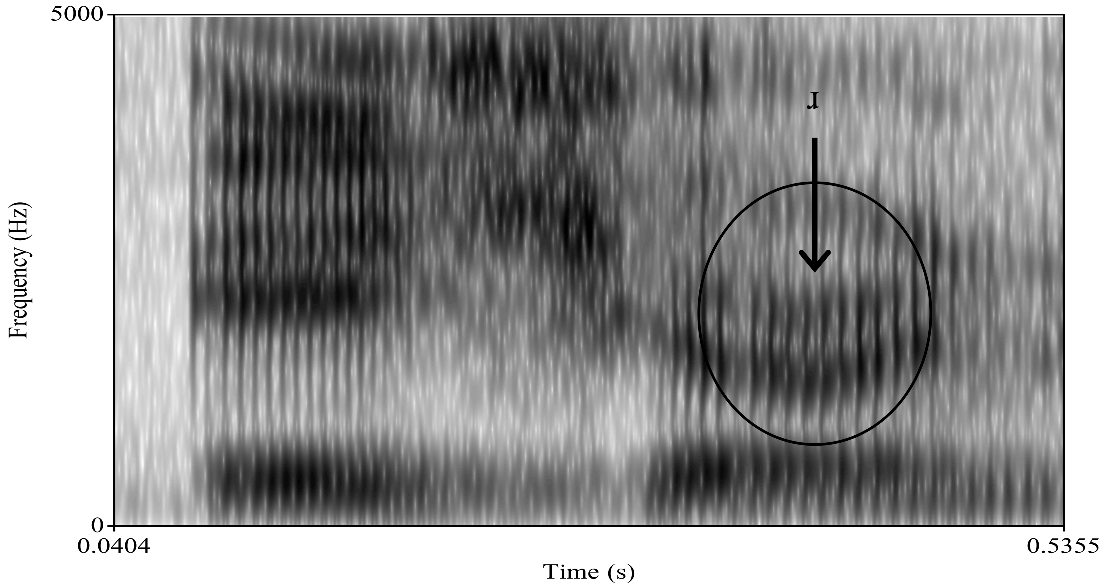

Figure 6.18: Realisation of the post-alveolar approximant [ɹ] as an intrusive /r/ (word boundary) – 'Asia and' (Speaker cm13, read speech)

6.1.2.2 Effects of non-linguistic factors on acoustic variation

In analysing F3-F2 distances of Scores 2 and 4 (i.e. strong labiodental approximant [ʋ] and strong post-alveolar approximant [ɹ]), besides evidence of only speech style effects, there are also those of interactions between speech style and ethnicity, on differences within and between the two. The approximant /r/ variants are first considered individually.

Across all four ethnic groups, Score 4 (i.e. strong post-alveolar approximant [ɹ]) realisations always have wider F3-F2 distances, therefore are always weaker, in reading than in conversation. Additionally, Score 4 (i.e. strong post-alveolar approximant [ɹ]) realisations amongst the ethnic groups are more unalike in reading and more alike in conversation. However, although there are more distinctive acoustic differences when weaker Score 4 (i.e. strong post-alveolar approximant [ɹ]) realisations are produced, SgE speakers appear to employ a common strategy of increasing the degree of labialization (i.e. higher F2 transition values in reading than in conversation) in the process.

For Score 2 (i.e. strong labiodental approximant [ʋ]) realisations, there are effects of interactions between speech style and ethnicity. While ethnically Chinese, Eurasian and Indian SgE speakers produce Score 2 (i.e. strong labiodental approximant [ʋ]) realisations with narrower F3-F2 distance, therefore stronger, in reading than in conversation, ethnically Malay SgE speakers have stronger Score 2 (i.e. strong labiodental approximant [ʋ]) in conversation than in reading although only very slightly. Here, regardless of differences in effects, most SgE speakers make use of stronger labialization in producing a weaker approximant /r/; this time, in the form of Score 2 (i.e. strong labiodental approximant [ʋ]) realisations. This is with the exception of ethnically Chinese SgE speakers who rely more on manipulating retroflexion.

These findings thus suggest that Score 4 (i.e. strong post-alveolar approximant [ɹ]), with its regularity in speech style and ethnicity effects, is an established /r/ variant in SgE while

Score 2 (i.e. strong labiodental approximant [ʋ]) is an emergent /r/ variant which shows a characteristic emergent instability in the attitudes towards the feature amongst ethnic groups depicted through differences of speech style effects, and in the understanding and treatment of its production shown through the differing strategies of labialization and retroflexion.

Comparing speech style effects between the approximant /r/ variants (i.e. Score 2 - strong labiodental approximant [ʋ] and Score 4 - strong post-alveolar approximant [ɹ]) revealed more interactions with ethnicity. Evidence that, for all four ethnic groups, Scores 2 and 4 (i.e. strong labiodental approximant [ʋ] and strong post-alveolar approximant [ɹ]) differ acoustically in similar ways across speech styles is robust. In both reading and conversation, Score 2 (i.e. strong labiodental approximant [ʋ]) always has steeper F2 transition, flatter F3 transition and wider F3-F2 distance than Score 4 (i.e. strong post-alveolar approximant [ɹ]).

However, despite the fact that the directions of differences between Score 2 and 4 (i.e. strong labiodental approximant [ʋ] and strong post-alveolar approximant [ɹ]) are the same in both speech styles for all ethnic groups, there are differences in the size of effect when comparing them across speech styles for most ethnic groups except for ethnically Eurasian SgE speakers. The acoustic distinctions between Scores 2 and 4 (i.e. strong labiodental approximant [ʋ] and strong post-alveolar approximant [ɹ]) for ethnically Eurasian SgE speakers remain relatively the same in both reading and conversation. The acoustic differences between Score 2 (i.e. strong labiodental approximant [ʋ]) in reading and in conversation are also comparable with those of Score 4 (i.e. strong post-alveolar approximant [ɹ]) in reading and in conversation for these speakers. This shows that ethnically Eurasian SgE speakers are generally consistent in their realisations of both types of approximant /r/, showing relative invariable distinctions between variants and across speech styles. This could be attributed to the fact that, for them, cross-linguistic influences are not an issue as most ethnically Eurasian SgE speakers reported using almost entirely English only. Although they had all learnt second languages (i.e. Mandarin/Malay) in school and had obtained GCE O-level qualifications in them, these languages have not been brought out of the school context and used in everyday interactions. Even if they were, it was always only in code-mixing contexts in casual situations which involved conversational partners of these other languages for the purposes of goods and services (e.g. interactions with hawkers at local food centres). Their parents and grandparents also have English as their dominant language and are generally far removed from the languages of their ancestors (e.g. Spanish, Portuguese, Kristang). English, for this group of SgE speakers, is thus relatively stable at this point although a recent revival of Kristang, is likely to effect some change in the future.

For ethnically Chinese and Malay SgE speakers, there are significantly fewer acoustic differences between speech styles for Score 2 (i.e. strong labiodental approximant [ʋ]) than for Score 4 (i.e. strong post-alveolar approximant [ɹ]), and the acoustic distinctions between Scores 2 and 4 (i.e. strong labiodental approximant [ʋ] and strong post-alveolar approximant [ɹ]) is less in reading than in conversation. This meant that ethnically Chinese and Malay SgE speakers realised Score 2 (i.e. strong labiodental approximant [ʋ]) across different speech styles more similarly and made more distinctions across speech styles for Score 4 (i.e. strong post-alveolar approximant [ɹ]). What is shown is also that distinctions made between Scores 2 and 4 (i.e. strong labiodental approximant [ʋ] and strong post-alveolar approximant [ɹ]) by these two groups of SgE speakers are generally wider in conversation than in reading.

Ethnically Indian SgE speakers, conversely, make more distinction between Scores 2 and 4 (i.e. strong labiodental approximant [ʋ] and strong post-alveolar approximant [ɹ]) in reading than in conversation. And, for them, Score 2 (i.e. strong labiodental approximant [ʋ]) is more unalike between speech styles than Score 4 (i.e. strong post-alveolar approximant [ɹ]). It appears then that for both ethnically Chinese and Malay SgE speakers, realisations of Score 2 (i.e. strong labiodental approximant [ʋ]), that are undoubtedly distinct from Score 4 (i.e. strong post-alveolar approximant [ɹ]), have become quite natural with little differentiation made between speech styles although the strategies used differ, likely due to cross-linguistic influences. However, for ethnically Eurasian and Indian SgE speakers, the latter group to a greater extent, efforts seem to be made in differentiating not only the realisations of Score 2 and 4 (i.e. strong labiodental approximant [ʋ] and strong post-alveolar approximant [ɹ]) but also those of Score 2 (i.e. strong labiodental approximant [ʋ]) between speech styles. This ties in with the overall analysis of frequency of occurrences and the preliminary conclusions from the analysis of age effects across ethnic groups for which ethnically Chinese SgE speakers of the middle age group, who are found to realise Score 2 (i.e. strong labiodental approximant [ʋ]) most frequently, are hypothesized to be leading the change in the realisation of Score 2 (i.e. strong labiodental approximant [ʋ]) in SgE, followed by ethnically Malay SgE speakers from the lower age group and then by their ethnically Eurasian and Indian counterparts – this will further elaborated in Section 6.4.

6.1.3 Tap [ɾ]/Trill [r]

Tap [ɾ]/Trill [r] realisations are not usually studied and/or reported in SgE. This is likely to be due to their infrequent occurrence; this study finds that the tap [ɾ]/trill [r] is indeed the rarest /r/ realisation in SgE. However, it also shows that a discussion of /r/ in SgE which excludes these /r/ variants would be an incomplete portrayal, one which does not reflect the vital multicultural-multilingual characteristic, of SgE. Further discussions of the sociophonetic aspect of this will be covered in Sections 6.2 and 6.3. Evidence from the auditory analysis show that the tap [ɾ]/trill [r] in SgE occurs in the same syllable-initial and intervocalic positions as the post-alveolar approximant [ɹ] and the labiodental approximant [ʋ]. Some examples are given in Figures 6.19 – 23.

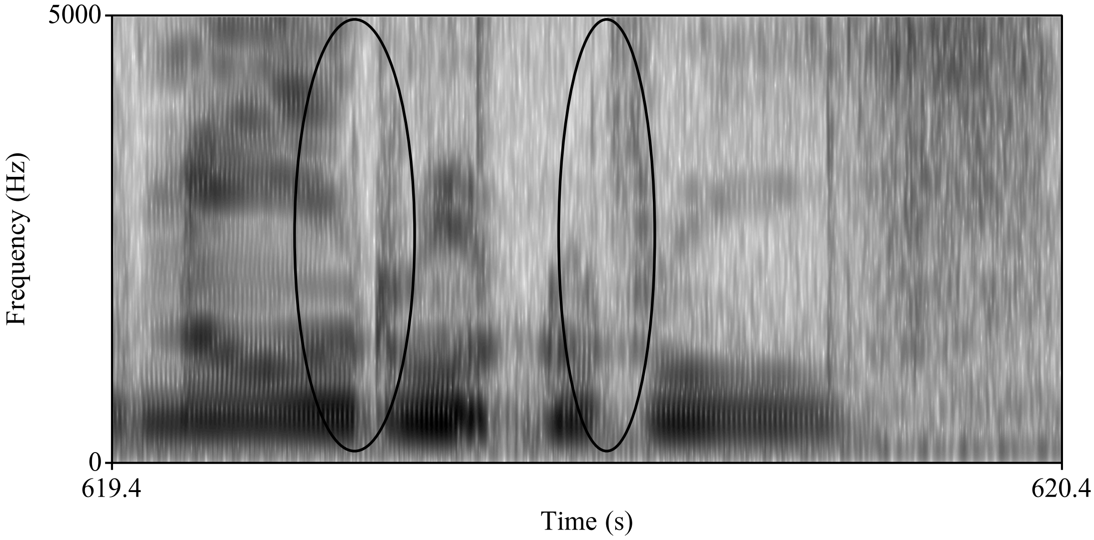

Figure 6.19: Realisation of the tap [ɾ]/trill [r] in syllable-initial word-boundary positions – ‘road rules’ (Speaker mf1, conversational speech)

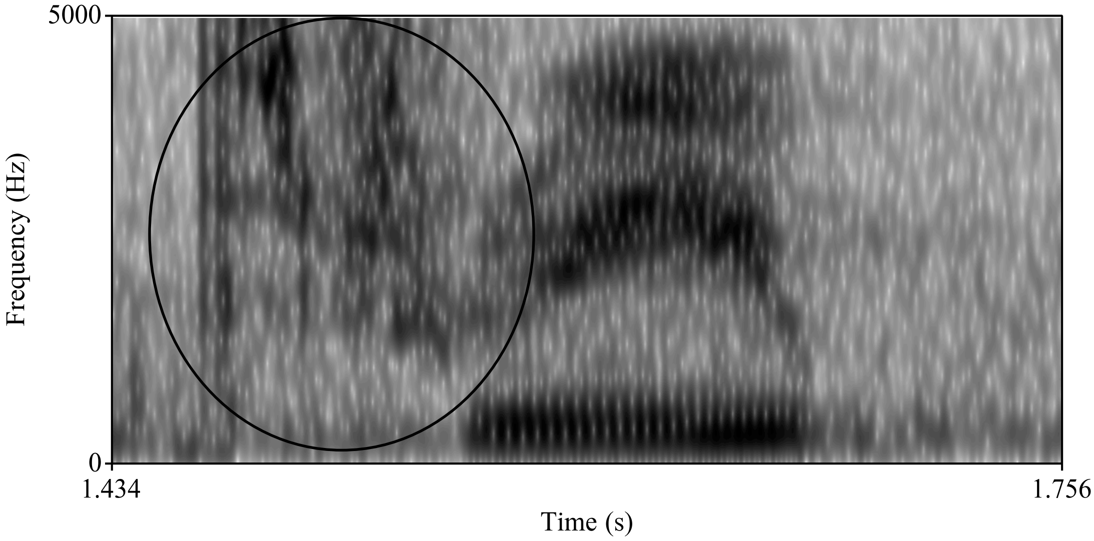

Figure 6.20: Realisation of the tap [ɾ]/trill [r] in a syllable-initial consonant cluster (word boundary) – ‘three’ (Speaker if7, conversational speech)

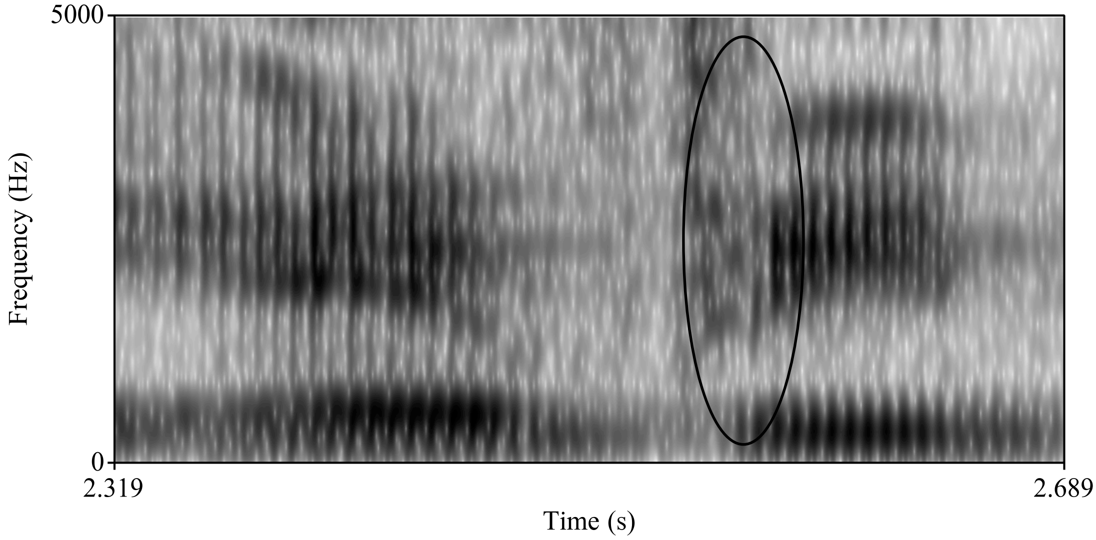

Figure 6.21: Realisation of the tap [ɾ]/trill [r] in a syllable-initial consonant cluster (word internal) – ‘every’ (Speaker mm1, conversational speech)

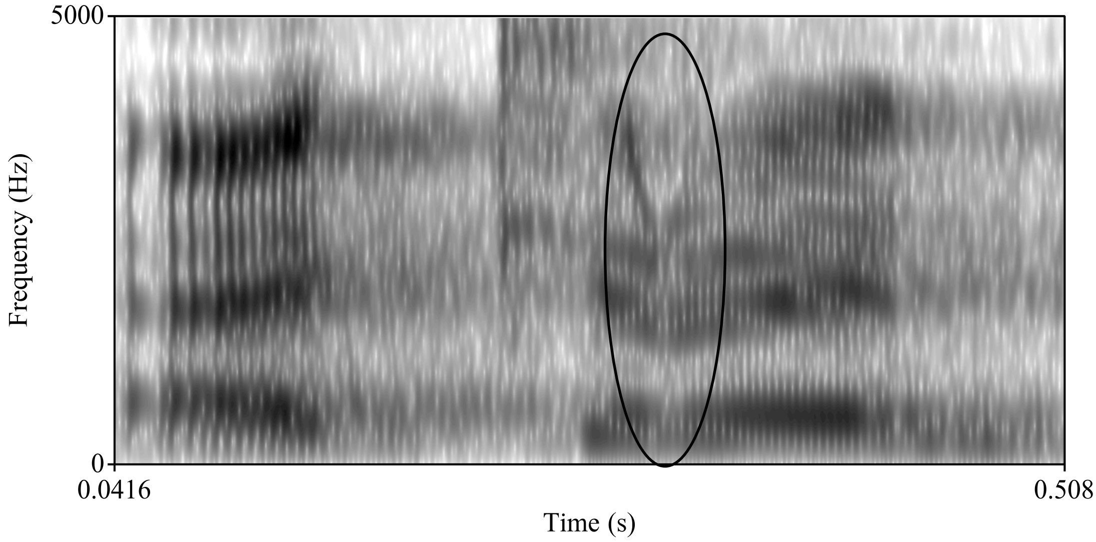

Figure 6.22: Realisation of the tap [ɾ]/trill [r] in an intervocalic (morpheme internal) position – ‘accurate’ (Speaker im4, read speech)

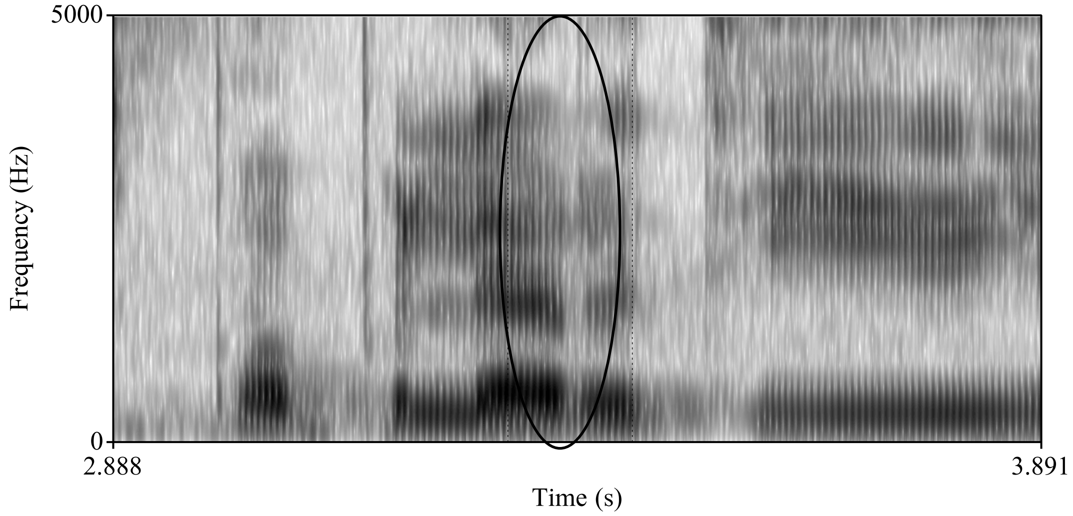

Figure 6.23: Realisation of the tap [ɾ]/trill [r] in an intervocalic (morpheme boundary) position – 'popularity' (Speaker mm1, read speech)

As with the labiodental approximant [ʋ], there are restrictions when the tap [ɾ]/trill [r] is realised in syllable-final positions. As reported in Sections 4.2 and 4.5, it only occurs as linking /r/ in syllable-final prevocalic contexts (see Figure 6.24)

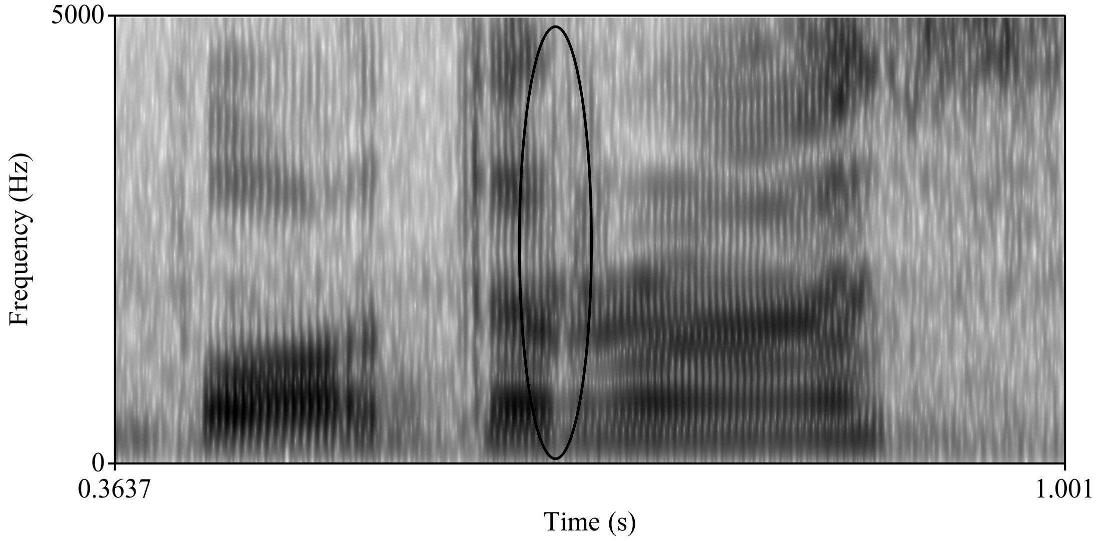

Figure 6.24: Realisation of the tap [ɾ]/trill [r] in a syllable-final prevocalic (word boundary) position (i.e. linking /r/) – 'bother us' (Speaker if3, read speech).

It appeared that the tap [ɾ]/trill [r] is also found in word-internal syllable-final non-prevocalic position but this was rare. In fact, this only occurred in the conversational speech of Speaker mm5 solely for the word 'Turkish' (see Figure 6.25). Therefore, the proposition is that this occurrence is atypical and, as in this case, likely to be limited to words derived from a language (i.e. Turkish) with the tap [ɾ] in its phonology. No tap [ɾ]/trill [r] realisations were found to occur in syllable-final consonant clusters (e.g. apartments, cart) and all other syllable-final non-prevocalic positions (e.g. car, poor boy), including intrusive /r/ contexts.

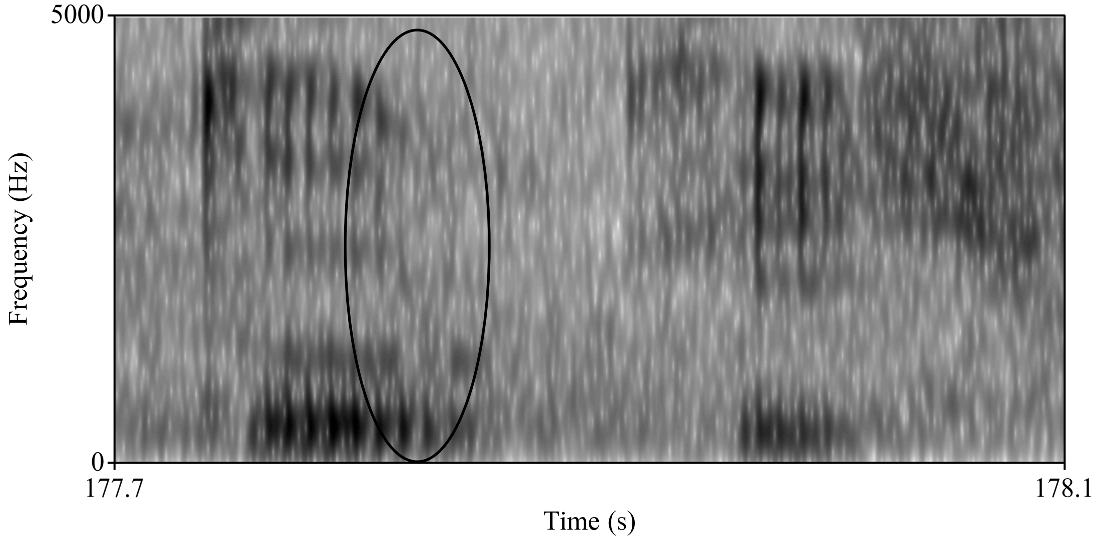

Figure 6.25: Realisation of the tap [ɾ]/trill [r] in a syllable-final non-prevocalic (word internal) position – 'Turkish' (Speaker mm5, conversational speech).

Observing the acoustic features of tap [ɾ]/trill [r] in SgE revealed that these realisations are, at times, signalled by lowered F3, steep F3 transitions into following contexts, comparatively flatter F2 transitions into following contexts, and narrow F3-F2 distances (see Figure 6.19). However, this was not always the case, with some tap [ɾ]/trill [r] realisations having high F3s, flat F3 transitions and wide F3-F2 distances (see Figure 6.23). At the same time, while most tap [ɾ]/trill [r] realisations have the characteristic period(s) of break, this too was not guaranteed. There exist realisations which are perceptually clear tap [ɾ]/trill [r] yet do not show clear breaks in spectrograms. This usually occurs in consonant clusters as seen in

Figures 6.20 and 6.21. This finding therefore echoes studies of /r/ in which no single acoustic characteristic has been found that links all /r/ sounds but, rather, /r/ sounds have been seen as participating in a network of family resemblances in several dimensions (e.g. Lindau, 1985).

With these findings, it should be reiterated that considering multiple acoustic measures (e.g. F3-F2 distance, F2 transition, F3 transition) in the analysis of /r/ in SgE is necessary to account for the most salient acoustic measures and all for the different articulatory strategies employed in realising the different variants of /r/. It is certain at this stage of the discussion that these three variants (i.e. post-alveolar approximant [ɹ], labiodental approximant [ʋ] and tap [ɾ]/trill [r]) occur in (socially influenced) free variation in non-syllable-final positions, and while the post-alveolar approximant [ɹ] occurs in all syllable-final positions, it is rare for the labiodental approximant [ʋ] and tap [ɾ]/trill [r] to be realised, even if in syllable-final prevocalic (word boundary) position. The discussions that follow will propose factors affecting the variation in /r/ in SgE as reported in this section.

6.2 Variability of /r/ realisation in Singapore English: The effects of linguistic factors

Both the auditory and acoustic analyses showed the complexity that arises in understanding a multifaceted system like SgE. The fact that there are multiple factors that could contribute to variation and that analysing the interactions between them would probably be the more valid way to study a multicultural variety makes the process extremely challenging. It is thus clear that considering factors in insolation for a variety like SgE, which exists only as a sum of its parts, would be erroneous. Therefore, a multidimensional approach to studying variation in a community like this is necessary. The next sections discuss the intricate nature of /r/ variation in SgE in three broad areas – effects of linguistic factors, effects of speech style, and cross-linguistic/language dominance influences.

A further investigation of the factors affecting the variation in type of /r/ variant realised in SgE, as described in Section 6.1, revealed that this variability is triggered significantly by several language internal processes and some levels of interactions between them.

As a considerably lower number of syllable-final /r/ observations was found, it was necessary to analyse and report non-syllable-final and syllable-final /r/ separately. This was explained in Section 4.2. The following discussion therefore generally follows this practice.

6.2.1 Non-syllable-final /r/

This study's auditory analysis indicated that for non-syllable-final environments, when considering the effects of phonological position, most variation occurs in consonant clusters. Syllable-initial consonant clusters can thus be said to cause most variability in /r/ realisation in SgE.

From the statistical analysis conducted in the auditory analysis, significant effects were found in the occurrence of null realisations (i.e. Score 0), weak labiodental approximants (i.e. Score 1) and weak post-alveolar approximants (i.e. Score 3). The probability of null realisations and these perceptually weak approximant /r/ variants occurring in syllable-initial consonant clusters is significantly higher than in the other two non-syllable-final positions (i.e. intervocalic and syllable-initial positions). These patterns indicate that syllable-initial consonant clusters encourage the realisations of perceptually weaker variants (i.e. Scores 1 and 3) within both approximant /r/ variants. This is supported by syllable-initial consonant clusters also being the highest likely position for null realisations to occur.

There is a significantly higher probability of strong labiodental approximant [ʋ] (i.e. Score 2) occurring in syllable-initial positions and syllable-initial consonant clusters than intervocalically, in line with what was previously found for the labiodental approximant /r/ in SgE (Kwek, 2012). And, in a slightly different pattern, the occurrence of the strong post-alveolar approximant [ɹ] (i.e. Score 4) is significantly more likely in syllable-initial and intervocalic positions than in syllable-initial consonant clusters. Here, it can be seen that a syllable-initial position is most likely to promote the realisations of the strong variants of both types of approximant /r/ (i.e. Score 2 - strong labiodental approximant [ʋ], Score 4 - strong post-alveolar approximant [ɹ]). The higher probability of a strong labiodental approximant [ʋ] (i.e. Score 2) occurring in a syllable-initial consonant cluster than intervocalically, however, sets it apart from a strong post-alveolar approximant [ɹ] (i.e. Score 4) for which a syllable-initial consonant cluster is the least likely phonological position it is predicted to occur in. This further evidences syllable-initial consonant clusters as the strongest phonological position predictor for perceptually weaker variants, thus suggesting a general weakening of approximant /r/ (from Score 4 to 0 on the scale) in SgE triggered by the complexity of the onset.

Word class effects were found, in further support of the role of complex onsets on the occurrence of perceptually weaker /r/ variants in SgE, and additionally indicating that the status of a class as a content word or a function word needs to be considered as a contributing factor as 'function words … are more susceptible to reductive or weaking sound changes, probably due to the low sentence stress typical of function words' (Phillips, 1983; Jurafsky et al, 1998 in Phillips, 2011). The likelihoods of /r/ in syllable-initial consonant clusters realised as weak variants of both approximant /r/s (i.e. Score 1 - weak labiodental approximant [ʋ], Score 3 - weak post-alveolar approximant [ɹ]) were predicted to increase further if they occurred in function words instead of content words. The same was found for those in intervocalic position. At the same time, the probability of /r/ realised as a strong post-alveolar approximant [ɹ] (i.e. Score 4) in both syllable-initial consonant clusters and intervocalically decrease significantly if they occurred in function words instead of content ones. Furthermore, null realisations (i.e. Score 0) in these two phonological positions were also found to increase significantly if /r/ occurred in function words. Taken together, in SgE, it is clear that structural factors – both phonological (e.g. complex onsets) and grammatical (e.g. function words) support a higher probability of perceptually weaker /r/ variants.

In the same line of argument, following context was another contributing linguistic factor found to affect probabilities of perceptually weaker /r/ variants in SgE. While there is no evidence of following context effects on weak labiodental approximant [ʋ] realisations (i.e. Score 1), the pattern of following context effects was robust for weak post-alveolar approximant [ɹ] realisations (i.e. Score 3). This is seen particularly in the environment of /r/ followed by a mid-central vowel (i.e. schwa) which exists typically as an unstressed syllable.

Although the probability of a weak post-alveolar approximant [ɹ] realisation (i.e. Score 3) always significantly increased whenever /r/ was followed by a mid-central vowel in all phonological positions, the highest probability of occurrence was still found in syllable-initial consonant clusters. It can therefore be concluded that a higher occurrence of a non-syllable-final weak post-alveolar approximant [ɹ] realisation is conditioned by an unstressed syllable, in the form of a reduced mid-central vowel, particularly in the environment of a syllable-initial consonant cluster.

An effect of following context was also found for realisations of strong labiodental approximant [ʋ] (i.e. Score 2). Following high back and high front vowels significantly increase the probability of strong labiodental approximant [ʋ] (i.e. Score 2) realisations in all non-syllable-final phonological positions, indicating the influence of vowel height of following vowels on realisations of perceptually labialised variants of /r/. This is further supported by the contrastive pattern of increased probabilities of strong post-alveolar approximant [ɹ] (i.e. Score 4) realisations in all non syllable-final phonological positions when followed by low back rounded, low back unrounded and low front vowels. For these respective following contexts, syllable-initial remained as the phonological position in which both strong approximant /r/ realisations (i.e. Scores 2 and 4) occurred most frequently, lending stronger evidence for the role of vowel height in the distinction between the two approximant /r/ variants. These have indeed shifted the initial perspective of the most commonly occurring vowel after a labiodental approximant /r/ in SgE which was initially hypothesised to be back rounded vowels (Kwek, 2012). However, since the caveat on that preliminary finding was that it needed to be further studied and verified as it was only a by-product of the main purposes of that study which was not designed for an entirely reliable test for the effects of following contexts, the current study's results are eminently more valid.

6.2.2 Syllable-final /r/

As stated in Section 6.1, in SgE, /r/ can be realised in all syllable-final positions, namely syllable-final non-prevocalic, syllable-final consonant cluster, syllable-final prevocalic at word boundary (i.e. linking /r/) and intrusive /r/. There is variation, however, in terms of frequency of occurrences and /r/ variant realised.

Intrusive /r/ is found to be the least common occurrence when considering syllable-final /r/ for SgE. It only occurs in read speech style and as a strong post-alveolar approximant [ɹ] (i.e. Score 4). But, as mentioned, since observations of intrusive /r/ realisation were infrequent, and otherwise varied, this conclusion of intrusive /r/ occurrence needs to be taken with caution. At the same time, no other generalisable patterns of occurrence or causes of effect can be made.

Linking /r/, the other /r/-sandhi phenomenon, conversely, was a common occurrence in SgE. In fact, prevocalic /r/ realisation at word boundaries (i.e. linking /r/) is the most frequently occurring syllable-final /r/. In addition to frequency of occurrence, variation was also found in types of /r/ variants realized in syllable-final positions. While most of the syllable-final /r/ realisations are of a strong post-alveolar approximant [ɹ] (i.e. Score 4), there is a clear increase in probability of a tap [ɾ]/trill [r] (i.e. Score 5) occurrence if the /r/-realisation occurred as a linking /r/ in a function word. An overall increase in probability of occurrences of strong post-alveolar approximant [ɹ] and tap [ɾ]/trill [r] realisations in this prevocalic (word boundary) position compared to the other syllable-final positions together with the fact that it is the only syllable-final position in which the tap [ɾ]/trill [r] (i.e. Score 5) occurs strongly suggest that this phonological position encourages perceptually stronger /r/ realisations.

6.3 Sociophonetic variation of /r/ in Singapore English: Trends and Implications

Alongside language internal factors, language external factors (i.e. speech style, speaker sex, ethnicity) were found to contribute to the /r/ variation discussed. Some sociophonetic trends emerge from analysing the effects of these factors, reinforcing the importance of not only taking a multidimensional approach to understanding /r/ variation in SgE but also of understanding that social stratification is inevitably present in any community and so will play significant roles in the variation and/or change that happens, features of speech and therefore /r/ variation included.

6.3.1 The extent of speech style effects

Including the speech styles of reading and conversation in this study was for the purpose of representing careful deliberate utterances as opposed to casual natural speech. As expected, speech style was found to have significant effects on the realisations of /r/ in SgE.

Null realisations, which had non-significant differences in the probability of their occurrence in the various non-syllable-final positions were, as expected, always more likely to occur in conversation than in reading. This finding reflects other cases of natural speech processes where less deliberate, more natural, potentially faster-paced connected speech makes for an ideal context for weakening/deletion whereas orthography, which is more visually-accessible to a speaker in the context of read speech, may serve to remind readers of the potential presence of /r/. The direction of effects, however, was the reverse of what was hypothesized in some instances. Higher probabilities of weaker approximant /r/ variants occurring in casual speech seemed intuitively to be expected but this expectation was not always borne out in SgE, once again hinting at the possible effects of various competing levels of interactions.

Regardless of the other linguistic factors, phonological position and word form, for /r/ in non-syllable-final positions, perceptually weaker approximant /r/ variants (i.e. Score 1 – weak labiodental approximant [ʋ] and Score 3 – weak post-alveolar approximant [ɹ]) always had higher probabilities of occurrence in reading than in conversation. Additionally, effects of interaction between phonological position, word form and speech style were particularly outstanding for these weaker variants of both types of approximant /r/. Higher probabilities for perceptually weaker approximant /r/ variants occurring in syllable-initial consonant clusters of function words, as reported in Section 6.2.1, increased even further in reading while, in a directly reverse pattern, the lower probabilities of their perceptually stronger approximant /r/ variant counterparts (i.e. Score 2 – strong labiodental approximant [ʋ] and

Score 4 – strong post-alveolar approximant [ɹ]) occurring in the same phonological position, word form and speech style decreased further. Consequently, these provide evidence for an environment, created by a combined contribution of linguistic factors (i.e. complex onsets and function words) and speech style (i.e. deliberate careful speech), in which perceptually weaker approximant /r/ variants were more likely to occur than their perceptually stronger counterparts. Based on these findings, in particular the fact that the strong variants of both approximant /r/s have higher probabilities of occurring in casual natural speech, there is reason to conclude that besides the typical post-alveolar approximant [ɹ] realisation, there is not only the presence of a labiodental approximant [ʋ] but also a relative stability in its specification as an emergent /r/ variant in SgE.

In all syllable-final positions, it can be concluded that there is a higher probability of /r/-realisations occurring in read speech, especially in content words. Three different hypotheses could be made for this. As mentioned earlier, the fact that seeing the orthographic 'r' in the spelling while reading could, to some extent, encourage syllable-final /r/ realisations which otherwise would not occur. Syllable-final /r/ realisations found in these environments could also be said to mean that SgE speakers realise /r/ in syllable-final positions to sound more formal, and could even be extended to suggest that they deem a rhotic accent as more standard. It is, however, acknowledged that any strong generalisations of this hypothesis will only be possible through a further systematic sociolinguistic study of attitudes and beliefs but as it is beyond the aims of the current study, caution is taken not to over inflate its viability. What does further support it, in this study, is the fact that /r/ realisations in the following potentially similar phonological positions were found to be significantly different - syllable-final prevocalic at word boundaries (e.g. *car is*), intervocalic (e.g. *forest*, *recurring*), and syllable-initial following a vowel (e.g. *he ran*), indicating that syllable-final /r/ are indeed treated differently. The third hypothesis involves an attribution to the effects of ethnicity, implying cross-linguistic influences particularly those of the Malay and Indian languages in which syllable-final /r/ realisations are present. This final hypothesis will be revisited in the next section as, at this point, the effects of interactions between speech style and ethnicity on non-syllable-final realisations of Scores 2 and 4 (i.e. strong labiodental approximant [ʋ] and strong post-alveolar approximant [ɹ] respectively), which also suggest cross-linguistic influences, will be discussed first.

6.3.2 Cross-linguistic influences and language dominance

6.3.2.1 Non-syllable-final /r/

Phonological position effects on /r/ realisations for both Scores 2 and 4 (i.e. strong labiodental approximant [ʋ] and strong post-alveolar approximant [ɹ] respectively) are not further affected by the read speech style. For all ethnic groups in read speech, the highest probability of Score 2 (i.e. strong labiodental approximant [ʋ]) occurring was consistently in syllable-initial position, followed by syllable-initial consonant clusters, and lowest in intervocalic position. For Score 4 (i.e. strong post-alveolar approximant [ɹ]) in read speech, the order of probability of occurrence in the various phonological positions remained unchanged and was the same for all ethnic groups as well – the highest in syllable-initial position, then intervocalically and least likely in syllable-initial consonant clusters. However, some levels of interaction in conversational speech exist. There are some differences between ethnic groups, in casual spontaneous speech, in the phonological position which triggers highest probabilities of Scores 2 and 4 (i.e. strong labiodental approximant [ʋ] and strong post-alveolar approximant [ɹ]) occurrences.

In conversations, ethnically Malay SgE speakers have a higher probability of producing Score 2 (i.e. strong labiodental approximant [ʋ]) in syllable-initial consonant clusters than syllable-initially while ethnically Chinese, Eurasian, and Indian SgE speakers do not exhibit any difference in phonological position effects between speech styles in the probabilities of their Score 2 (i.e. strong labiodental approximant [ʋ]) realisations. Ethnically Eurasian, Malay, and Indian SgE speakers, however, do have a higher probability of producing Score 4 (i.e. strong post-alveolar approximant [ɹ]) intervocalically than syllable-initially in conversations while ethnically Chinese SgE speakers show no differences in the effects of phonological position between reading and conversation for Score 4 (i.e. strong post-alveolar approximant [ɹ]). It appears, not unexpectedly, that less deliberate connected speech conditions cause more complex onsets (i.e. consonant clusters) to encourage weaker, more fronted /r/ variants in SgE (i.e. Score 2 - strong labiodental approximant [ʋ]). However, this was only the case for ethnically Malay SgE speakers. As most ethnically Malay SgE speakers self-reported as using and/or coming into contact with languages other than English (i.e. Bahasa Malay, other Indonesian languages) with family and friends on a regular basis, cross-linguistic influences are once again brought into the picture. It is therefore hypothesized that /r/ variation in the emerging labialised /r/ variant is highly affected by language internal factors for ethnically Malay SgE speakers who have the influence of other languages which have stronger /r/ variants, particularly in casual spontaneous connected speech. The reason for the effect of speech style on phonological position of Score 4 (i.e. strong post-alveolar approximant [ɹ]) was less clear. What can be concluded here, nonetheless, is that SgE speakers, when producing non-syllable-final /r/, generally behave more similarly in reading than in conversation regardless of /r/ variant.

6.3.2.2 Syllable-final /r/: Rhoticity

Returning to the discussion of ethnicity effects on syllable-final realisations, ethnically Malay SgE speakers are found to have the highest probabilities of realising syllable-final /r/ regardless of word form. While there is no interaction found between ethnicity and speech style as it is true across all ethnic groups that there are higher probabilities of syllable-final /r/-realisations in reading than in conversation, an interaction between ethnicity and word form is seen in the Indian ethnic group. Ethnically Indian SgE speakers, unlike everyone else, realise syllable-final /r/ more in function words than in content words in both speech styles. This thus suggests that in addition to the hypothesis that SgE speakers, in general, produce syllable-final /r/ in more formal contexts, there is also the possibility of syllable-final /r/ realisation as a more natural occurrence for ethnically Indian SgE speakers due to cross-linguistic influences. Besides the fact that Tamil was the other language spoken by these speakers, basic sociolinguistic interviews conducted also revealed that some of them were in fact Tamil language teachers, at the point of recording, who report Tamil as their dominant, and most proficient, language. This supports the proposition of the influence of Tamil in which /r/ is realized in syllable-final positions.

Tangentially, the hypothesis of cross-linguistic influence appears to also be applicable to ethnically Malay SgE speakers. Not only are they the ethnic group with the highest probability of syllable-final /r/ realisations, the differences between both speech styles for them are also small, suggesting a level of naturalness in the presence of syllable-final /r/ realisation in their variety of SgE. While all ethnically Malay SgE speakers report English to be the language of choice in formal and social settings (i.e. work/school/play), the majority of them, as mentioned earlier, report having Bahasa Malay in their linguistic repertoire, and family members and friends as their usual conversational partners for the language. Some even state that while they may not necessarily have conversational proficiency in the Indonesian languages of their sub-ethnic groups (e.g. Javanese), they are able to comprehend what is being said. Moreover, even if they are not personally effective users of the Indonesian languages, they have grown up and/or are currently immersed in a linguistic environment in which these languages are used. Some of their immediate family members (e.g. parents, grandparents) regularly watch Indonesian television programmes and either use these languages at home or amongst relatives in Malaysia and Indonesia with whom they maintain close contact. Together, these give evidence to the possibility of cross-linguistic influences on syllable-final /r/ realisations for ethnically Malay SgE speakers.

The cross-linguistic influences as discussed so far seem to work in the same way in the occurrences of Score 5 (i.e. tap [ɾ]/trill [r]) realisations for both ethnically Malay and Indian, and even some ethnically Chinese SgE speakers. As mentioned at the start, discussions on the realisations of taps/trills in SgE are rare. The occurrence of taps/ trills are usually associated with ethnically Malay and Indian SgE speakers and rarely, if at all, with ethnically Chinese and Eurasian SgE speakers. However, the current study reports occurrences of taps/trills for SgE speakers of all major ethnic groups. It is acknowledged that there is variation in the likelihood in occurrence and, impressionistically, the realisation of taps/trills is commonly expected to index ethnicity. Although appearing to be true, it might be too superficial to assume the effect of just ethnicity. Instead, it is imperative that the focus should be on cross-linguistic influences of other languages spoken by SgE speakers in which these /r/ variants exist (i.e. Malay/Indonesian and Indian languages) rather than on the ethnic group which is usually linked to these languages. Support for this suggestion can be seen in the occurrences of taps/trills in ethnically Chinese SgE speakers. Upon further analyses of the personal and language background details collected from participants, it was found that the ethnically Chinese SgE speakers who were found to use taps/trills had, in fact, Peranakan ancestry (a description of the Peranakans was given in Chapter One). Influences from Peranakan Malay were thus also found to apply similarly to the realisations of taps/trills for ethnically Chinese SgE speakers with Peranakan backgrounds. These speakers, like their Malay counterparts, do not necessarily have communicative proficiencies in the language but are naturally susceptible to cross-linguistic influences through growing up with and living in regular communication with their parents and grandparents who do.

6.4 Change in /r/ in Singapore English: preliminary observations and predictions for the future

This study has shown strong evidence for various levels of /r/ variation in SgE. It also contributes some initial observations of the patterns of change and of what might potentially be the future of /r/ in SgE.

What looks to be a strong direction for /r/ in SgE is the continued presence of the labiodental approximant /r/ which might eventually become an equally commonly occurring variant as the post-alveolar approximant /r/. In the preliminary analysis of age effects on non-syllable-final /r/ realisations, as presented in Section 4.2, it is seen that besides occurring quite substantially in most subgroups of SgE speakers, some patterns of ethnicity and age effects can be seen. Ethnically Chinese female and male SgE speakers from the middle age group (i.e. late 20s – late 30s) were found to have the most labiodental approximant realisations. This age group of speakers are also the 'young SgE speakers' found to have a prominent occurrence of the labiodental approximant in their speech in earlier studies (Deterding, 2007; Kwek, 2005, 2012). It seems like they have retained the /r/ variant and the prediction is that they would continue to do so in the future as they become part of the upper age group, which at the moment show low occurrences of labiodental approximant realisations. The current lower age group of ethnically Chinese SgE speakers, those in their late teens to early 20s, also, like the upper age group, was found to not have as many occurrences of the labiodental approximant realisation. This was unexpected as it has been purported as an emergent feature that is popular with young speakers. However, observing the occurrence of the labiodental approximant /r/ in the different age groups of other ethnic groups, a pattern is observed. The labiodental approximant /r/ still is indeed an emergent feature that is seen in young SgE speakers but looks to be conditioned also by ethnicity. Young ethnically Malay SgE speakers are found to have high occurrences of the variant, comparable to the occurrences in the middle age group ethnically Chinese SgE speakers. The middle age group ethnically Malay SgE speakers, however, do not have as many labiodental approximant /r/ occurrences. From this, it appears that the ethnically Chinese SgE speakers are leading the change in the emergence of the labiodental approximant /r/ in SgE, with the ethnically Malay SgE speakers following closely. There is no telling if the popularity of the labiodental approximant /r/ will return for the young ethnically Chinese SgE speakers but, from this preliminary finding, the prediction is that the labiodental approximant /r/ will be a common /r/ variant for a good number of years.

With the naturally-occurring language-internal process of /r/ weakening as well as the presence of taps/trills and rhoticity in SgE, it appears that, again, the fate of these could go either way dependent on competing language-internal and language-external factors. There has been a rise in the revival of ‘ancestral languages’ (e.g. Kristang) in the Singapore society recently, as mentioned earlier in Section 6.1.2.2, together with sentiments of local/national pride. It is not surprising, then, if young SgE speakers start picking up the other languages (e.g. Chinese languages, Indonesian languages, Baba Malay) which in turn have cross-linguistic influences on SgE. This seems quite possible, also further reinforced with the government’s covert realignment of language policies as seen in the celebration of Singlish and use of the other Chinese languages (or dialects, as they are known in the Singapore context) in the media. Relatedly, SgE is in a stage of growth and has speakers who speak English as their first language, taking pride and ownership in the language and consequently deeming external standards to be impositions rather than emulations. This will result in change driven by local norms. However, there could also be change parallel to those in varieties of English that are perceived as prestigious and/or attractive to SgE speakers as, after all, there is still a good number of SgE speakers who look to these external norms as the standard to follow.

6.5 Limitations of current study and future directions

Discussions in this study have revolved around analyses of patterns of variation in SgE at a group level as typically done in variationist sociolinguistic studies, and these have yielded valid and interesting results. What has not been explored in this study, however, is individual speaker variation which is acknowledged to be an interesting aspect of variation. This was not included in the current study as the approach to doing so, as seen in Clark and Watson (2016), is through analysing random intercepts from an LME model. As described in Chapter 4, there were limitations in using the LME model in that the treatment of the study's multinomial outcome variable as a continuous ordinal one made for estimates that were not logically interpretable. The same problem is extended in the interpretation of random intercepts and random slopes. As such, it was decided that not including an analysis of individual speaker variation was the safer approach, to avoid the risk of unreliable results.

Another limitation of this study was in the generalizability of findings for Score 5 (i.e. tap [ɾ]/trill [r]) and syllable-final /r/ realisations, particularly the former. As these features are not extremely widespread in SgE, the eventual sample size, although enough to be computable in the statistical analyses, was only strong enough for preliminary claims about the trends that surfaced. Further investigations need to be carried out to provide stronger evidence for the hypotheses of cross-linguistic influence and language dominance. A proposed approach is to extend the investigation of /r/ realisations in ethnically Malay SgE speakers with Indonesian ancestry and in ethnically Chinese SgE speakers with Peranakan ancestry, and to include a cross-generational study of these two groups of SgE speakers. Additionally, the extent of cross-linguistic influences and language dominance could also be further studied for Tamil-speaking ethnically Indian SgE speakers. As SgE speakers of this group who reported having Tamil as their dominant language were found, in the current study, to have particularly higher probability of tap [ɾ]/trill [r] realisations compared to others with the same linguistic repertoire but reported having English as their dominant language as well as others who also reported to have English as their dominant language but speak another

Indian language (e.g. Punjabi, Sindhi, Hindi), investigating this further should provide clearer evidence of the influence of Tamil on SgE. It would also be interesting if /r/ realisations in Tamil spoken by the same speakers were studied and both auditory and acoustic comparisons made with those in SgE. The same could be done with ethnically Indian SgE speakers who have the other Indian languages (e.g. Punjabi, Sindhi, Hindi) as their dominant languages as similar cross-linguistic influences might also be found. This could, however, not be entirely feasible as the use of these languages is slowly decreasing in the Singapore context with many of their speakers now choosing to either speak only English and/or even learning Mandarin in school.

The next step in studying the labiodental approximant [ʋ] in SgE would be to track not only its variation but also its change. This stems from the preliminary analysis of age effects in the current study, as discussion in the previous section, which hints at the possibility of a downward trend in popularity after an initial surge, as seen in the observably higher frequency of occurrence in ethnically Chinese female SgE speakers in their late 20s – 30s than in those in their late teens – early 20s. Taking both a synchronic and a diachronic approach, if possible, in this study, involving a good number of speakers in three distinct age groups (i.e. 17 – 23, 27 – 41, above 50), would be ideal in this endeavour and should surface interesting patterns in the development and status of the labiodental approximant [ʋ] in SgE.

Furthering the current acoustic analysis, exploratory statistical analyses (e.g. factor analyses) on the acoustic data can be carried out to consider whether, and how, these provide further evidence for the auditory categories. Additionally, the role of the preceding segment on /r/ realisation could also be investigated as these might surface more evidence of coarticulatory effects and contribute to the discussion of /r/ variation conditioned by language-internal factors. This proposed investigation is, resultantly, predicted to also provide more details on the nature of syllable-initial consonant clusters and how they contribute to /r/ weakening in SgE.

In addition to the auditory and acoustic analyses of the production of /r/, it would also be beneficial to carry out auditory and acoustic studies on the perception of /r/ variants and their related sounds. These will give further evidence to the acoustic cues that are salient for the variants of /r/ in SgE, enabling a more comprehensive understanding of /r/ variation in SgE.

What would also be interesting to carry out is an attitudinal test which provides insights into how Singaporeans of different ages and linguistic backgrounds feel towards the use of the labiodental approximant [ʋ] and the tap [ɾ]/trill [r] variants. This would contribute a different perspective to the understanding of their variation and change in SgE.

6.6 Concluding remarks

This study of /r/ variation in SgE shows a situation consisting of the co-existence of perceptually strong and weak approximant /r/ variants, the presence of three perceptually and acoustically distinctive /r/ variants (i.e. labiodental approximant [ʋ], post-alveolar approximant [ɹ] and tap [ɾ]/trill [r]) in free-variation in non syllable-final positions. It extends previous acoustic investigations of approximant /r/ which commonly only focus on lowered F3, and at times F2, to one that shows the benefits of an acoustic analysis which combines F2 and F3 transitions from /r/ to its following context, and the distance between F2 and F3. By doing so, it is able to suggest an account of different strategies involved in /r/ realisation (i.e. labialisation, retroflexion). It also reiterates the claim that there is no one phonetic property that binds all /r/ sounds, as discussed in the models of /r/ variation (Lindau, 1985; Magnuson, 2007; Sebregts, 2014) in Chapter Two, and also that the presence of between- and within-speaker variation in /r/ realisation makes finding the 'link' between /r/ sounds all the more challenging.

Besides reasserting the post-alveolar approximant [ɹ] as the dominant /r/ variant in SgE, results also showed trends of a tap [ɾ]/trill [r] that is waning in occurrence and a relatively stable emergent labiodental approximant [ʋ]. It serves not only to confirm the findings of preliminary studies done (Kwek, 2005, 2012) showing the presence of the labiodental approximant [ʋ] but also further provides new evidence showing that its occurrence and the entire picture of /r/ variation in SgE is formed by a combination of linguistic and non-linguistic factors (i.e. phonological position, word form, following context and speech style) as well as that of speech style and cross-linguistic influences. This shows similarities to various other detailed studies of /r/ variations (e.g. Rennicke, 2015; Sebregts, 2014), in which factors like phonological position, following contexts, and cross-linguistic influences have all been found, although in different manners and to different extents. Contributing a better understanding of the linguistic environment and its influences on /r/ in SgE in turn informs us more generally of how /r/ variation might be for the varieties/languages that share communities of speakers with similar environments/backgrounds – this of which is lacking in the field.

Highlighted through the findings of this study is the fact that a consideration of multidimensional effects is especially necessary for analysing variation in young, urban, multicultural varieties of English like SgE where there are inevitable competing effects of not only global communication and local identity but also concurrent influences of the community and the self, which are all constantly changing. The complexity of these competing volatile factors and how speakers of varieties like SgE are required to constantly juggle them makes a straightforward analysis challenging. Nonetheless, it is not impossible as proven in this sociophonetic study of /r/ variation in SgE. This study has contributed a fuller representation of SgE with its inclusion of SgE speakers of various linguistic and cultural backgrounds and in this way has highlighted various aspects of /r/ variation in SgE that have not been previously discussed. And while there is still much to be discovered, this study has now laid a strong foundation for a continuing study of the Singapore English story of /r/.

Appendix A

Acknowledgement of Consent

ACKNOWLEDGEMENT OF CONSENT

You have agreed to participate in a linguistic study run by **Geraldine S.C. Kwek**, a PhD student in the Department of Theoretical and Applied Linguistics (DTAL) at the University of Cambridge. Please read each of the following statements. If you wish to proceed with the study, please tick each of the boxes below.

If you have any questions, please contact **Geraldine S. C. Kwek, gsck2@cam.ac.uk**

Thank you.

- ☐ I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, and without my rights being affected.

- ☐ I understand that the data collected for this research project will be kept confidential; all data will be identified by a random code that is not linked back to me and will be kept in a secure location.

- ☐ I understand that these data may be presented at professional conferences or in academic manuscripts. These results will be written up based on group data. If, in rare instances, individual data might be used, then no identifying information will allow others to trace my responses back to me.

- ☐ I understand that there will be no financial profits from my participation in this study.

- ☐ I have the name and email address of the researcher.

- ☐ I agree to take part in the study.

Full name: ______________________________________

Signature: ______________________________________

Date : ______________________________

Appendix B

Participant's Information Sheet

UNIVERSITY OF CAMBRIDGE
DEPARTMENT OF THEORETICAL AND APPLIED LINGUISTICS
PHD STUDY
'A STUDY OF SPOKEN SINGAPORE ENGLISH(ES)'

PARTICIPANT'S INFORMATION SHEET
SPEECH PRODUCTION

Please rest assured that your personal particulars provided here will be kept confidential and will only be available to the researchers of this study. Your identity or that of anyone mentioned in the recordings will not be revealed. Thank you very much for your participation.

<u>Personal Details</u>

Full Name		**Gender**	
Age		**Ethnicity**	
Father's Ethnicity		**Mother's Ethnicity**	
Nationality (if not Singaporean)		**Occupation**	
Email Address		**Contact Number**	
**Please provide at least 1 mode of communication*			

[Please proceed to page 2]

Other countries you have lived in (only if applicable):		
Country	**Period of stay**	**Length of stay**

Schools you have attended (please also include your post-secondary schooling):		
Level	**Name**	**Country**
Pre-Primary		Singapore
Primary		Singapore
Secondary		Singapore

Highest Attained Education/Current Education Level:

[Please proceed to page 3]

<u>Language Profile</u>

Languages you speak:**		
Language	**Starting age**	**Interaction Partners**

***Please also include dialects*

Of the above stated languages, which in your opinion is your	
1)	**dominant^ language?**
^The language that you use most of the time	
2)	**most proficient^^ language?**
^^The language that you speak best	
3)	**language of choice[#]?**
[#]The language that you are most comfortable speaking and would choose to use if a choice was available	

[Please proceed to page 4]

Interaction Partners:

Top of Form

Do you interact regularly (i.e. at least on a weekly basis) with a speaker/speakers of another non-Singaporean variety of English?

Yes ☐ No ☐

If 'Yes', please specify the following.

Bottom of Form

Variety	Frequency of Interaction	Purpose of Interaction

Your participation is greatly appreciated. Thank you for your patience.

Appendix C
Read Speech Materials

Short Passage - The Boy Who Cried Wolf

Please read the following passage

There was once a poor shepherd boy who used to watch his flocks in the fields next to a dark forest near the foot of a mountain. One hot afternoon, he thought up a good plan to get some company for himself and also have a little fun. Raising his fist in the air, he ran down to the village shouting "Wolf, Wolf!" As soon as they heard him, the villagers all rushed from their homes, full of concern for his safety, and two of his cousins even stayed with him for a short while. This gave the boy so much pleasure that a few days later he tried exactly the same trick again, and once more he was successful. However, not long after, a wolf that had just escaped from the zoo was looking for a change from its usual diet of chicken and duck. So, overcoming its fear of being shot, it actually did come out from the forest and began to threaten the sheep. Racing down to the village, the boy of course cried out even louder than before. Unfortunately, as all the villagers were convinced that he was trying to fool them a third time, they told him, "Go away and don't bother us again." And so the wolf had a feast.

Structured Sentences

Please read the following sentences.

S1.1	I must say that I enjoyed last night's play so much!
S1.2	A lion's something I would never dare rear.
S1.3	Christmas is my favourite holiday as there are always many presents under a beautiful tree.
S1.4	There are many approaches to presenting the issue but his is a poor angle.
S1.5	Asia and Africa are considered to be a single continent by some.
S1.6	Please replace the cartridge for that printer as we need more ink to print the poster.
S1.7	I really think that red bird is already dead.
S1.8	The MRT is usually ridiculously packed; I strongly recommend taking the bus.
S1.9	This is an exciting car race.
S1.10	The car park was extremely run down last year.
S1.11	The bear is so hungry that it is rummaging through the bin and eating everything.
S1.12	They were ranked highly last year but achieved poor rankings this year.
S1.13	I ate fried rice for breakfast on Friday morning.
S1.14	My neighbours are home now but they were out earlier.
S1.15	This English writer has won three prizes so far.
S1.16	Richard offered her ale when they went to the pub last week.
S1.17	This flight really frightened me thoroughly.
S1.18	Will you be able to attend the meeting this Sunday evening?

S1.19	When I was abroad, I made bread myself.
S1.20	We saw four otters along the coast in California.
S1.21	That mobile phone cover is the one I have been interested in purchasing.
S1.22	She led that raid against the enemy.
S1.23	He is a well-known car ace.
S1.24	However nice it was, no one wants to choose a school with a poor ranking.
S1.25	This is the fifth time I am asking you this question.
S1.26	That ERA agent specialises in apartments located in the far east of Singapore.
S1.27	It is common sense not to leave an open flame near ice cubes.
S1.28	It's a tradition to eat one spoon of pure honey every day.
S1.29	If you won't do it, then dare Ian.
S1.30	I have forgotten my best friend's birthday; I am in such deep trouble!
S1.31	I still cannot believe that out of six eggs, we had four rotten ones.
S1.32	The spectators watched intently as the car raced past.
S1.33	I realise that courage can be learnt.
S1.34	They are constantly raving about their perfect marriage.
S1.35	The containers were round but now they are square.
S1.36	There has been recurring news of the volcanic eruption.
S1.37	Sara finally got a chance to meet her real mother.
S1.38	The farmers live near rice fields to facilitate their long working hours.
S1.39	It has been said that opportunity only knocks on the door once.

S1.40	Are you sure this can absorb the liquid?
S1.41	We travelled all the way but they were out of those delicious cupcakes.
S1.42	That car is tremendously old so arrangements should be made to scrap it.
S1.43	Ice-skating is so popular that they need more rinks for everyone.
S1.44	My fear of oranges is absurd to many.
S1.45	Which cafe has an ambience which you like the least?
S1.46	That car aced its competitors in this year's popularity rankings.
S1.47	The man who was loitering outside the bank was arrested by the security guards.
S1.48	The poor boy cannot afford to get another pork bun.
S1.49	Her eel dish was not very fresh.
S1.50	Accurate data analysis is vital in research done in all fields.
S1.51	The cookies may not look it now but I swear they were round!
S1.52	She fell into a pothole while running and hurt her poor ankle.
S1.53	You should be giving up the seat to that old lady, shouldn't you?

Word List Set

Please read the following sentences.

S2.1	Please say fruit again.	S2.18	Please say cut again.
S2.2	Please say flour again.	S2.19	Please say snails again.
S2.3	Please say pawed again.	S2.20	Please say rough again.
S2.4	Please say four again.	S2.21	Please say crowd again.
S2.5	Please say cloud again.	S2.22	Please say poured again.
S2.6	Please say ship again.	S2.23	Please say flower again.
S2.7	Please say sneers again.	S2.24	Please say wail again.
S2.8	Please say tweet again.	S2.25	Please say tore again.
S2.9	Please say leave again.	S2.26	Please say flute again.
S2.10	Please say veal again.	S2.27	Please say sorry again.
S2.11	Please say berry again.	S2.28	Please say fall again.
S2.12	Please say flash again.	S2.29	Please say taw again.
S2.13	Please say laugh again.	S2.30	Please say live again.
S2.14	Please say sheep again.	S2.31	Please say treat again.
S2.15	Please say sorely again.	S2.32	Please say real again.
S2.16	Please say rail again.	S2.33	Please say belly again.
S2.17	Please say cart again.	S2.34	Please say flesh again.

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