PERCEPTION OF ACCENTS AND DIALECTS IN ADULTS AND INFANTS

by

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Perception of accents and dialects in adults and infants

Abstract

This thesis has been undertaken with the purpose of investigating how adult speech processing systems are affected by, and how they cope with, the presence of different regional and foreign accents in speech, and to investigate the developmental origins of adult accent perception capabilities.

Experiments 1 to 4 were designed to investigate the long term effects of exposure to different accents, and whether short term adaptation to an accent was possible, using a lexical decision task. The results demonstrated an effect of accent familiarity but no short term adaptation was evident. Experiments 5 to 7 investigated the short term effects of accents by looking at the length of activation of accent-related information in working memory by using a cross-modal matching task. The results found that selective accent related effects were reduced after a 1500 millisecond delay.

Experiments 8 to 11 investigated infants' discrimination abilities for regional and foreign accents using a preferential looking habituation method, and found infants at 5 and 7 months could discriminate their own accent from another, unfamiliar regional accent, but could not discriminate two unfamiliar regional accents at 5 months or a foreign accent from their own at 7 months. Experiments 12 and 13 investigated how accents affected infants' word segmentation abilities with continuous speech at 10 months, and found that segmentation was impaired in the presence of regional and foreign accents.

Using these results, the Accent Training Model (ATP) is proposed, which attempts to explain how accent related indexical information is processed in the speech processing system. The findings of the infant studies further our understanding of the effect of indexical variation in early speech perception.

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Author's declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without the prior agreement of the Graduate Committee.

This study was funded by a PhD studentship grant from the EPSRC. Relevant scientific seminars and conferences were regularly attended, at which work was often presented. In addition a research paper was prepared and has been submitted for publication, as well as other publications where I have contributed.

All the experimental carried out in this thesis was conducted by myself, including literature review, selection of stimuli, design of experiments, data collection and analysis, and discussion of results, except for Experiment 13, which was contributed by Maria Egielman, and the data was presented as part of her Master's thesis. She worked under my close supervision for stimuli, design, data collection and analysis.

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Introduction

Due to advances in communication technologies, such as telecommunications and the internet, the world is becoming a smaller place. For instance, it is now very common to connect a games console to the internet and compete against, and interact with, other gamers in other countries. Through the use of headsets, these gamers can talk to each other while playing. For this reason, accent[1] stands out as a source of variability in speech because we are more likely to encounter accented speech that we do not necessarily have experience of. When attending a conference, it is not unusual to be presented with a non-native speaker of English, or a native speaker from another English speaking region or country. It is usually the case that the first few sentences heard are difficult to comprehend, however, with further exposure, we experience an adaptation so that our comprehension of what is produced improves. These situations illustrate a classic issue in psycholinguistics: decades of research in phonetics and automatic speech recognition have established how extremely variable the speech signal is, depending on speakers' characteristics such as gender, dialect, accent, speech rate, emotions, etc. Yet as adults, when spoken to in our maternal language, we understand most of what we hear in various listening conditions, showing our remarkable ability to adjust to, or to normalise the speech signal. How does this adaptation take place? What are the processes underlying these rapid adjustments? How does this remarkable system develop? Explaining how we adjust to variability in speech has always been, and still is, a challenge for any model of word recognition.

This thesis examines how our perceptual system processes and adapts to a particular source of variation, accents and dialects. Until recently, the study of dialects had been mainly carried out within a socio-linguistic perspective (Chambers, Trudgill and Schilling-Estes, 2005), focusing on describing dialectal characteristics and explaining changes across communities and time. Only a few years ago psycholinguists started investigating perception of accents and dialects, following the impetus given by the

[1] Following Wardhaugh (1992), the term accent refers to the language varieties spoken by communities from various regions of the world, within a given language (Standard English for example). Grammar and vocabulary are similar, only pronunciation differs.

development of new models of word recognition in which more emphasis was given to the role of variability in lexical representations (e.g. Johnson, 1997; Goldinger, Pisoni, and Logan, 1991). Amongst the different kinds of variability in speech, dialects and accents are special: variations are found both at the acoustic and the linguistic level, on the contrary to gender or speech rate differences which translate in acoustic changes. That is, two voices may differ because one person's pitch will be higher than the others, or because one person's voice onset time (VOT) will be shorter than another person's VOT (e.g. Morris, McCrea and Herring, 2008). However two dialects may differ not only, for example, because absolute VOT values differ, such as between American English and British English (Baart and McMahon, 2006), but also because phonological rules may differ. For instance, American English is characterized by flapping of plosive sounds, which is not usually found in standard British English, a phenomenon which follows complex phonological rules, depending for example on stress placement and following phonemes (Eddington and Elzinga, 2008). Given these observations it is particularly interesting to investigate how word recognition models can integrate the normalisation of accents and dialects, as this type of variability should tap onto every stage of word recognition, from acoustic and phonetic representations to the lexicon.

The accent normalisation process, as any other kind of signal normalisation mechanism, is a two-stage process, namely initial comprehension disruption followed by adaptation leading to total or partial recovery of baseline comprehension. Its psychological reality has partially received empirical support over the past few years. Initial language processing impairments due to foreign accents have been noted in a number of studies, and have been found to affect syntactic, semantic and lexical processing (Floccia, Goslin, Girard and Konopczynski, 2006; Lane, 1963; Munro and Derwing, 1995; Shmid and Yeni-Komshian, 1999; Van Wijngaarden, 2001; Weil, 2003). Evidence for subsequent adaptation to foreign accent offers mixed conclusions, with studies reporting significant reduction of the initial impairment (Clarke, 2000; Gass and Varonis, 1984; Bradlow and Bent, 2008; Clarke and Garrett, 2004; Weil, 2001; Wingstedt and Schulman, 1987) and others who reported no such adaptation in laboratory situations (Jongman, Wade and Sereno, 2003; Adank and McQueen, 2007; Floccia, Butler, Goslin and Ellis, 2009b). It is not clear from previous studies under what conditions adaptation to an accent is possible, and, following recent investigation of initial impairment due to regional and foreign accent presentation (Adank and McQueen, 2007; Floccia et al., 2006), the first aim of this project is to examine the time-course of a possible adaptation to these varieties in adults. This thesis will examine whether first it is possible to evidence a short-term and a long-term adaptation effect to regional and foreign accents in laboratory conditions, and second whether the word identification impairment due to unfamiliar accent presentation originates in prelexical processing or at the lexical level.

The secondary aim is to understand the developmental origins of these processes by comparing adult accent perception to that observed during the first year of life, when infants are in the process of building up phonological representations for their maternal language. Just as we learn our maternal language, we learn a particular dialect in this maternal language, and which dialect we will retain as adults is mainly determined by peer pressure at school (e.g. Fischer, 1958; Kerswill and Williams, 2000; Starks, 2002). Recent findings have shown that babies as young as five months can discriminate between two varieties of their native language (Nazzi, Jusczyk and Johnson, 2000), and that between five to seven years of age, children are unable to perceive regional accent information in speech (Floccia, Butler, Girard and Goslin, 2009a; Girard, Floccia and Goslin, 2008). In an attempt to obtain a full developmental picture of accent perception between infancy and adulthood, a series of experiments at five, seven and ten and a half months will be carried out to examine what kind of dialect-related information is encoded by young infants.

For clarity purposes, the adult literature review will be exposed first, together with the studies conducted in this research, followed by the developmental issues and the related experiments. In the adult part, different models of lexical access will be examined to demonstrate how they can account for accent-related information normalisation. Then evidence will be presented from the literature relating to accent perception in adults, and then present a set of experiments designed to investigate effects and adaptation mechanisms for accent variations in adults. The infant part will expose early phonological development in infants, and present evidence of early accent perception. Then experiments designed to explore the effects of familiar and unfamiliar accents on infants' discrimination and word segmentation abilities will be presented.

In order to eliminate confusion, the key terms used throughout this thesis will now be defined. When referring to accent, this relates to the features of speech that characterise where the speaker originates from, such as a Spanish speaker will speak English with a Spanish accent. Accent usually refers to a more general language classification of speakers and in particular, non-native speakers of English. In contrast, dialect refers to regional variations within a particular language that deviate from the standard variety of the language, such as the South West of England dialect. In this case, dialect refers to the phonetic differences that characterise speech within a language, such as r colouring after vowels in words such as "farm", that is found in South West varieties of English but not the South East. However, in this thesis, both South West and South East dialects would be classified as English accents. The intelligibility of speech refers to the ability to understand the message that is being conveyed by the speaker, whereas the comprehensibility of speech refers to the perceptual and cognitive effort necessary in order to identify the intended word.

One of the key themes of this thesis relates to our abilities to perceive and process accented speech. Normalisation relates to the process, presumably at the prelexical level, where speech is stripped of irrelevant surface variations (such as accent) in order to transform speech into an abstract idealised form. It is thought that this process is necessary for lexical access to occur, if words are stored in an abstract form. Adaptation to an accent refers to improvement of intelligibility and comprehensibility of the perception of the accented speech through exposure to a particular accent. Linked to adaptation, familiarity with an accent refers to the amount of exposure to that particular accent. Familiarity in this case relates to the amount of exposure over a substantial period of time, in terms of months and years, so that the familiarity with the accent allows sufficient time to learn to process the accent. Finally, short term refers to whether adaptation can occur during immediate exposure to an accent, whereas long term refers to whether adaptation has occurred through exposure over a longer period (related to familiarity with an accent). Short term adaptation refers to whether the listeners is able to adjust their perception of accented speech as they are being exposed to it (for example, as they are listening to the spoken sentences they are able to adapt and improve their perception of the speech, so that their comprehension of the speech has improved for the later heard sentences). Long term adaptation refers to whether the listener is able to adjust their perception of accented speech permanently so that, when they encountered the same accent later (i.e. weeks/months later), their perceptual systems shows improved comprehension from the initial exposure to the accent.

Chapter 1

Literature review of adult accent perception

Models of lexical processing in adults

In order to effectively communicate with others we need to be able to quickly and efficiently process tokens of speech that we encounter in order to ensure that we give the correct response. Decades of research in psycholinguistics have identified a series of universal components in the architecture of the language comprehension system. Amongst these, a *prelexical stage* corresponds to the extraction of phonetic and phonological information from the input, and the *mental lexicon* contains semantic and phonological information about the words to be recognised. This thesis concentrates on these two stages in the language comprehension system (which entails higher levels of processing such as a syntactic parser), and will focus on how the presence of accents in speech affects processing at these two levels.

In order to be able to identify words, we need to access our mental lexicon to match the input that we receive to our stored representations of what words mean. There are several models of spoken word recognition that have been proposed to account for how lexical access occurs. The first section will discuss the most important of these models and the second section will examine how they can handle the accent normalisation issue.

The first model proposed by Forster (1976) is a search model of word recognition. He suggested that the word recognition system is divided into two components, or "bins", one of which contains the orthographic properties of a word and the other contains the phonetic properties of the word. These bins are ordered in terms of descending order of frequency, so that most frequently occurring words are searched first. This model assumes that a single comparator will compare the incoming signal to the lexical representations stored in either bin until a match is found. From this match, a pointer to an entry in the master lexicon is retrieved, which provides further semantic properties of the word received in the input. This model assumes a bottom-up processing method, and as such is not directly influenced by other factors such as syntactic or semantic information. A criticism of the original search model was that, due to the single comparator that compared the input to the two components, this could lead to problems in explaining how rapid word recognition is possible due to the high number of files that would need to be searched (Carroll, 1998). In order to account for this Forster (1987, 1989, cited in Carroll, 1998) revised his model so that there is now a separate comparator for each component.

In contrast to the Search model, Morton's (1969) Logogen model suggested a system which assumes multiple word candidates are processed in parallel. A logogen is a representation of each word in the lexicon which specifies various attributes of the word, such as semantic, orthographic and phonological. A logogen is activated when a pre-designated threshold is reached, and so the word is recognised. Activation can occur in two ways. Firstly, features of the sensory input are matched to the logogen as they are detected. As more features are detected and matched to the logogen, a "score" accrues until the threshold is reached. Secondly, contextual information (semantic and syntactic structure of a sentence) is used to influence the activation of specific logogens. If you hear the sentence "I am going to the train ...", it is possible to assume that the next word you will hear is "station". Therefore the pre-designated threshold for the word "station" will be temporarily lowered because of the contextual information available, and so the logogen for "station" will be activated sooner, and the word is recognised quicker. It is assumed that these two systems work in parallel with each other in order to efficiently recognise words.

The two models described above suggest two different approaches to lexical access, a serial versus a parallel activation system. The Cohort model (Marslen-Wilson, 1987) appears to be an attempt to capture and integrate the best features of these two models. It was initially designed to account for auditory word recognition, and in particular to account for how listeners are able to recognise words very quickly and for their sensitivity to the recognition point of a word.

There are three stages in the Cohort model. The first, the access stage, is where an initial set of lexical candidates is activated, based upon the initial phonetic analysis of the speech signal (using bottom-up processing). For example, upon hearing "ba", bag, bat, bath, bass, etc. will become activated and added to the word initial cohort. During the second, selection, stage, the word initial cohort is now sensitive to other sources of information, such as phonetic input, word variables (i.e. frequency) and ongoing discourse content. Activation of some items in the cohort will drop off, while those that remain similar to the input signal will remain strongly activated. Therefore the items on the word initial cohort will be progressively eliminated until only one remains. This item then enters the third, integration stage, where the semantic and syntactic properties of the chosen word are integrated and utilised into a representation of the overall sentence.

One of the main advantages of the cohort model is its sensitivity to the temporal nature of speech. The word initial cohort is produced from the initial word sound, and as more of the word reaches the input the selection narrows down the options until only one choice remains. This would seem a logical process in order to recognise words as they are spoken.

A later version of this model has emerged, the distributed COHORT model (Gaskell and Marslen-Wilson, 1997). This version of the model suggests that lexical units are represented in a distributed pattern, which incorporates both phonetic and semantic information about each word. Word recognition follows a similar pattern to the original COHORT model, where speech input is mapped onto existing lexical knowledge using bottom up processing, so that as more input is received the network can move towards a point in lexical space which represents the word presented in the input. This version of the models differs in that it is able to make use of other, non-phonetic information such as context to guide the selection process, so that, when items still remaining in the word initial cohort fit the sensory input, context is able to influence the activation levels of the list items and so help select the correct word. This model also suggests a bottom-up inhibition process that ensures that, if the activated candidate no longer fits the sensory information available, context can be overridden, and the activation level of the candidate reduced.

A connectionist approach to word recognition is the TRACE model, proposed by McClelland and Elman (1986). This model takes the approach that context plays an important role in speech perception, and lexical context can directly assist acoustic-perceptual processing. Therefore this model suggests that information above the word level can directly influence word processing.

There are three levels in the TRACE model; input units, which relate to phonological features, and are connected to phoneme units, which in turn are connected to output units, which represent words. The levels are connected by excitatory connections which are bi-directional and so allow for both top-down and bottom-up processing. Between the units within levels are inhibitory connections so that, once a unit is activated, its competitors are inhibited. There are no inhibitory connections between levels. The input units are provided with energy from the speech signal, and so become "activated". This then spreads along the connections until only one output unit is left activated.

Another connectionist approach to word recognition is the Shortlist model (Norris, 1994). This is a similar model to TRACE, and consists of two stages. In the first stage, a bottom up process is used to perform an exhaustive lexical search which produces a list of potential word candidates which match the input. In the second stage, these candidates in this short list compete based on their bottom-up score that is related to the input. Once a word is placed in the list, it stays there until it is displaced by a higher scoring word.

Shortlist differs from TRACE in that words are only activated where there is some bottom-up evidence for it. Therefore lower levels are not influenced by information available from higher levels. In addition, activation only flows from phoneme level to word level.

Recently, an updated version of the Shortlist model, known as Shortlist B (Norris and McQueen, 2008) has been proposed. In contrast to the original model (now known as Shortlist A), Shortlist B takes a Bayesian approach to word recognition, whereas Shortlist A focused on activating potential matches based on the input. This means that word recognition is based on the probability that a word is recognised based on the evidence available. The authors argue that this Bayesian approach allows the model to provide an optimal word recognition system, which takes into account lexical competition, word frequency, perceptual match and mismatch and the relation between lexical and sublexical information. They also claim that Shortlist B generates insights into word recognition that activation based approaches cannot, such as how mispronunciations are not simply a case of impacting lexical access in terms of perceptual similarity (the level of activation varies depending upon how phonetically similar the mispronunciation is to the target word) but also the probability that a certain mispronunciation is more likely to be a certain target word over another.

A further model of word recognition is the Neighborhood Activation Model (NAM) proposed by Luce and Pisoni (1998). The basic premise behind this model focuses on how lexical items in memory are discriminated between, after activation based on stimulus input. The model assumes that acoustic-phonetic patterns are activated based on the input (patterns could correspond to words or non-words), and the number and nature of these lexical items activated are the factors used in determining the correct word. The number aspect relates to frequency of occurrence of each word, while the nature is concerned with the acoustic-phonetic similarity among the activated lexical items

A further model of speech perception is the Fuzzy Logical Model of Perception (FLMP) proposed by Massaro (1998, cited in Massaro and Cohen, 2000). This model suggests that we evaluate other perceptual sources of information (such as facial expressions) in order to provide overall support to all possible alternatives that could be matched to the stimulus input. This model suggests making use of many sources of information to come to a conclusion, rather than basing all judgements on simply matching incoming stimulus input to a stored representation.

The models of word recognition outlined above attempt to explain how we are able to process speech and identify words. One of the major issues that all these models have to face is to explain how we can recognise words in speech despite extraneous variation. Speech is a variable signal, mainly due to the presence of variations that provide information about the speaker, rather than the intended message, such as gender, speaking rate, speaking style and dialect (Pisoni, 1997). These sources of variation are referred to as indexical variability. Explaining how we deal with these variations is a challenge for models of speech perception. However most models of spoken word recognition focus on how we compare the incoming speech signal to our stored representation of words in our mental lexicon. As will be discussed in the next section, they seem to assume that some form of normalisation process occurs before recognition can take place, and so the problem of normalising variability in speech is not clearly addressed.

Processing of speech variability in models of lexical access

One of the major challenges facing any model of word recognition is how to deal with variability in speech (e.g. gender and speaking rate). In particular, no model has been designed specifically to deal with accent-related speech variation, and few have a direct bearing on accent adaptation. Forster's (1976; 1987; 1989) Search model suggests that the incoming speech signal is compared with lexical representations stored in a master lexicon in order to find a match. It would seem that the assumption in this model is that the speech signal is "cleaned" at a prelexical level, before it is compared with the lexicon, so that the representations that are stored would be abstract representations free of all irrelevant indexical information. Therefore, in order to deal with accent variation, the speech signal would go through some form of normalisation process in order to match the speech signal to the stored representations.

Similarly, Morton's (1969) Logogen model suggests a normalisation process at the prelexical level to remove all irrelevant information. Once this is done, the sensory input can then be matched to logogens stored in the lexicon, until the predesignated threshold is reached.

The Cohort model (Marslen-Wilson, 1987; Gaskell and Marslen-Wilson, 1997) is, again, another model which assumes a similar normalisation process. In this three stage model, an initial set of lexical candidates is activated based upon the initial phonetic analysis of the speech signal, which is then refined during the selection stage, using other sources of information, such as word variables and ongoing discourse content. In order for this to occur, the speech signal would need to be normalised before initial activation can occur in order to be able to effectively compare the speech signal to the stored abstract representations.

This assumption of a normalisation process also seems evident in connectionist approaches to word recognition. The TRACE model (McClelland and Elman, 1986) suggests the use of input units (which relate to phonological features), which connect to phoneme units which connect to output units relating to words. These units are connected by bi-directional excitatory connections, which activate output units based on sensory information to the input units. In order for this to occur, again the speech signal would need to be normalised in order to activate the correct units.

The Shortlist model (Norris, 1994; Norris and McQueen, 2008), another connectionist approach, attempts to answer the problem of variability. This approach (the latest version, Shortlist B) suggests that word recognition is based upon the probability that a word is recognised based on the evidence available. The authors suggest that by using this Bayesian approach, the model is able to take into account, for example, mispronunciations by working out the probability of the mispronunciation corresponding to a particular word, rather than just varying the level of activation based upon how similar the mispronunciation is to the target word, as in activation approaches. In this way, the model can also account for accent variability in speech, by working out the probability of the accented word to be a particular word.

The neighbourhood activation model (NAM, Luce and Pisoni, 1998) is another model that seems to assume that the speech input goes through some form of normalisation before word recognition can take place. This is an activation model in that word decision units are influenced by the acoustic-phonetic patterns in speech, which activates potential word matches, and then other forms of information, such as word frequency which are used to find the target word.

The Fuzzy Logical Model of Perception (FLMP, Massaro, 1998, cited in Massaro and Cohen, 2000) presumes that many different sources of information are evaluated both independently and then integrated to find the most likely word that is being presented. Although this model proposes that our recognition system utilises many other sources of information as well as the acoustic properties of speech, it again seems to assume that variation is eliminated before the evaluation process takes place.

All of the models mentioned above require some form of normalisation of the speech signal in order to deal with variability, but it is not clear how this normalisation is achieved. One way in which to think about how variations in speech affect perception would be to focus on how words are stored in the lexicon. There are two types of models which attempt to address this question; abstract entries models and exemplar based models.

According to Pallier, Colomé and Sebastián-Gallés (2001), abstract entry models assume that words stored in the lexicon are abstract representations that are free of variations such as accent, etc. They assume that the speech signal is normalised in a language specific way at the prelexical level. This normalisation process would modify the incoming speech signal to match the language representation of the individual before it can be matched to the abstract representations in the lexicon. This approach attempts to deal with variation by suggesting a normalisation process that is language specific and so removes information from the speech signal that is not relevant to our own representations. Pallier et al. present data from Spanish and Catalan bilinguals who were presented with word pairs in both languages which differed on phonemic contrasts. The crucial contrast was a Catalan phonemic contrast that is not present in Spanish. They found that Spanish bilinguals (whose language background was Spanish only at an early age) could not process this contrast because their representation of their first language, Spanish, did not possess this contrast, and so when the normalisation process occurred, the two contrasting Catalan phonemes were normalised into the same Spanish phoneme. What this study demonstrates is that in order to cope with variations that are not part of our native language we adapt them to fit with our language specific representations. It would seem that rather than create a new representation to account for new variations, they are normalised. This suggests that, rather than create an exemplar for all possible variations, we fit variations as best we can into our abstract representations.

In contrast, an example of an exemplar based model was proposed by Johnson (1997). This model suggests that, rather than storing an abstract representation of each word in the lexicon, variability is actually used and encoded into the lexicon, thereby eliminating the need for a normalisation process. Therefore, when we encounter a new word, we would remember not just the acoustic-phonetic properties of the word, but also the variability associated with the newly encountered example of the word, such as accent. If this is the case, there would be a myriad of exemplars stored in the lexicon that would relate to an individual word. These exemplars would be grouped together based on acoustic similarities between them, so that the exemplars would be recognised as variations of the same word. This is an example of a "pure" exemplar based model, which, as Johnson points out, would require an unlimited memory in order to store all possible exemplars that we could encounter. This would therefore seem to be impossible, and as such the model needs to be refined in order that not every possible exemplar is stored (which Johnson discusses). However, this "pure" exemplar model can be used in order to explain how this model would deal with variability in speech.

The way in which this model suggests that we deal with variability appears simple. By storing exemplars of each word within a category, this model eliminates the need for a normalisation process, as the speech signal can be compared directly to the stored representations. However, looking at accent variation, when encountering a new accent, we would not have had any previous experience of this, and so we would need to encode these new exemplars into our memory. This would lead to an initial impairment in processing, which should disappear once the encoding has taken place. We would also need to be able to process variability initially in order to understand what we are hearing and therefore successfully encode this word into the correct category. This would suggest some form of normalisation process when we are dealing with previously unencountered variability in speech.

Another aspect associated with explaining how variability can affect speech perception was demonstrated by McLennan and Luce (2005), who examined the time course of the effects of indexical information on spoken word recognition. They looked at speaking rate and talker identity, and used tasks that required either easy or difficult discrimination. An example of one of their tasks was a lexical decision task in which participants were required to decide whether a word heard was a real word or a made up, nonword. The difficulty of this task was controlled by either using nonwords that were very obviously not real words (e.g. thushthudge), or nonwords that were very similar to real words (e.g.bacov). They found that when processing was easy (i.e. quick), there was no effect of indexical information, however when processing was difficult (i.e. slow) indexical information affected participants recognition times. Their data suggest that indexical information only affects speech recognition relatively late in processing. The authors suggest that early in processing more abstract features of speech are more prominent and so the effects of indexical information are not evident. Then, during the later stages of processing, more specific detailed surface information now dominates. Therefore, this suggests an exemplar based approach to speech perception, an exemplar for all variations must be encoded if indexical information is to play a part in the latter stages of processing as suggested. They also suggest that the frequency with which exemplars are based impacts upon how quickly exemplars are activated, with the more often an exemplar is realised, the quicker it is activated, presumably because abstract features can then be used to activate the relevant representation.

The review of previous models of word recognition leads to the following hypotheses. The first hypothesis is concerned with abstract versus exemplar based models and familiarity with a particular accent. If word representations are stored in an abstract form, this would mean that, in order to successfully process accented speech, the speech signal would need to be normalised before this can occur. Therefore, an impairment would be evident when processing accented speech, and this impairment would remain regardless of our familiarity with the accent. This would be because, although our normalisation process may have improved through exposure to an accent, we will not have stored exemplars that match the accented speech, so will not be processed as quickly as our native accented speech. However, if exemplar based models are correct, and we store several exemplars for each word, then the initial impairment that would be evident when processing an unfamiliar accent would eventually be eliminated as we become more familiar with the accent through exposure, and we are able to store exemplars related to the accent. This hypothesis will be investigated in Experiments 1 to 4.

As most models assume some form of normalisation process, the next hypothesis is concerned with the nature of the normalisation process. When processing accented speech, one would expect to see an impairment compared with processing of native speech. However, if our processing system is given time to normalise the speech signal first, this impairment should be eliminated. It is possible that, through exposure, we are able to normalise a familiar accent more efficiently than an unfamiliar accent. Therefore, if processing of accented speech is immediate, then impairments should be evident for all accented speech. If processing is delayed, and our processing system has adapted to a familiar accent, this impairment should remain for the unfamiliar accent only. If we do not adapt to an accent through exposure, it is expected that the impairment would remain for both familiar and unfamiliar accents when processing is delayed. This will be investigated in Experiments 5 to 7.

In summary, although most models of word recognition assume some form of normalisation process before recognition occurs, there has been some attempt to explain variability processing, such as exemplar based models, which suggest that we encode and store indexical information in our lexicon in order to deal with variability. However, this leads to other problems, such as the amount of memory needed to encode all variability information in speech. There is also the problem of how we are able to process new variability that we have not encountered before. The next section will look at the literature relating to accent perception in adults, to get a full picture of how presentation of an accent actually impacts on word recognition processes.

Data on accent perception in adults

When we are talking about accents there are several different factors that need to be considered. Firstly, we need to consider how accents can affect speech perception (in the form of any initial impairments when encountering accented speech), and whether we are able to adapt to different accents in speech. Secondly, we have to ask whether the different types of accents, regional and foreign, affect processing in different ways. Regional accent refers to variations within the same language (e.g. speaker from northern and southern England speak with different accents, but for both areas their first language is English), whereas foreign accents refer to speakers whose own language is different (e.g. Spanish speakers who have learnt English as a second language after childhood will speak English with a Spanish accent). And thirdly, we need to consider how accents impact on the intelligibility and comprehensibility of speech. Speech is said to be intelligible if the message intended by the speaker is properly conveyed. This is usually evaluated by accuracy measures collected in orthographic transcription tasks (Derwing and Munro, 1997), repetition tasks (Wingstedt and Schulman, 1987), mispronunciation detection (Schmid and Yeni-Komshian, 1999) or sentence recognition tasks (Bent and Bradlow, 2008). Speech is comprehensible as a function of the perceptual and cognitive effort which was necessary to identify the intended word. This is usually measured by subjective ratings (Derwing and Munro, 1997) or reaction times (Clarke and Garrett, 2004; Floccia et al., 2006; Munro and Derwing, 1995; Weil, 2003). The next section will consider these factors and relate them to the evidence in the literature. Even though there is not extensive work in the literature about modelling accent adaptation in speech, several studies have collected some data on how adult listeners process and represent accent information.

The effect of accent on intelligibility and comprehensibility

Several studies have demonstrated the effect of accent on both the intelligibility and comprehensibility of speech. Schmid and Yeni-Komshian (1999) demonstrated how intelligibility was affected in a study which required native listeners to detect mispronunciations in speech produced by both native and non-native speakers. Participants were presented with sentences produced by four native English speakers and four non-native English speakers (one Castilian Spanish, one Puerto Rican Spanish and two Tamil accented speakers). Mispronunciations were created by changing a single phoneme (e.g. brook becomes drook), and participants were instructed to press the space bar as quickly as possible when they detected a mispronunciation. They found that listeners were both quicker and more accurate in detecting mispronunciations in speech when listening to native speech as opposed to non-native, foreign accented speech, suggesting that foreign accented speech requires more effort to process than native speech. In addition, they also found that responses to foreign accented speech were quicker when the target was more predictable (e.g. the mispronunciation "garpet" is easier to predict in the context "shag garpet" than "rag garpet"). What these results demonstrate is that the presence of an accent can distort the intended message that the speaker is trying to convey, which could lead to misunderstandings and miscommunications between both parties.

The effects of accent on comprehensibility was demonstrated in a study by Munro and Derwing (1995), who used a sentence verification task to determine whether a foreign accent would affect sentence processing times. They presented native speakers of English and native speakers of Mandarin with true/false statements that were thought to be easy for the listeners in this study to answer based on everyday knowledge (e.g. "Elephants are big animals", "Most people wear hats on their feet"). Each participant heard 40 statements, 20 from speakers of each accent group used, and were instructed to answer, using a response box as quickly and as accurately as they could. They were also required to transcribe each sentence after their response. Finally, after all 40 sentences were presented they were required to provide comprehensibility and accentedness ratings for each statement. Results showed that listeners took on average 30 ms longer to process Mandarin accented speech, and also made more errors, than for English accented sentences (although the number of errors for Mandarin sentences was still very small). They also found a relationship between the comprehensibility and accentedness scores, with a high level of accentedness leading to reduced comprehensibility. However, in some cases where comprehensibility was rated high, and sentences had been transcribed correctly, accentedness was also rated high, meaning that a strong accent did not necessarily mean that it was harder to understand.

Floccia et al. (2006) also demonstrated a perceptual cost to comprehensibility when processing a regional accent. They presented listeners from different regions of France with familiar and unfamiliar regional accents, and used a lexical decision task, where participants heard spoken sentences and had to decide whether the last word heard was a real word or a made up non-word. They found a processing cost of around 30 ms for the unfamiliar accent, and reported that the longer the sentence length presented to the participants, the larger the processing cost of the sentence. What this study demonstrates is that the additional processing that is necessary when processing accented speech has an adverse effect on comprehensibility, resulting in the reported delay associated with the unfamiliar accent.

Further evidence for a processing cost to comprehensibility associated with accents was shown by Adank, Evans, Stuart-Smith and Scott (2009), who used a true/false sentence verification task to investigate the effects of familiar and unfamiliar native accents and an unfamiliar non-native accent under adverse listening conditions. Participants were from either Southern England or from Glasgow (Scotland), and were chosen due to their perceived experience with the accents used in this study. The two native accents used were Standard English (SE) and Glaswegian English (GE), and participants from Southern England were screened so that they were unfamiliar with the GE accent. The Glasgow participants were thought to be familiar with both native accents due to the assumption that regional speakers would be more familiar with the standard variation of their own accent, plus the use of SE in the media, such as television. The non-native accent used was Spanish accented English (SpE). Speech shaped noise was added to the stimuli to add adverse listening conditions to the study. Adank et al. found that participants from Southern England were slower in responding to the unfamiliar native accent compared with the familiar native accent, whereas the Glaswegian participants were equally quick for both native accents. Floccia et al. (2006) demonstrated a similar effect in experiment 1, when Franche-Comte listeners (an Eastern region of France) were presented with Parisian French (the standard form of French) and Southern French, reaction times were equal for their familiar accent and the standard French, and they were slower for the unfamiliar Southern French. Returning to Adank et al.'s study, when presented with a non-native accent, participants from Southern England were slower to respond to this accent than to the native accents (Glasgow participants did not take part in this second experiment which used the non-native accent). The results of this study seem to suggest that familiarity to an accent impacts upon the processing cost, the more familiar an accent, the less the processing cost. This would suggest that adaptation to an accent should be possible through long term exposure.

What these studies show is that we do not process accented speech as easily as we process speech uttered in our native accent. There seems to be an initial processing cost associated with accented speech, both in intelligibility (Schmid and Yeni-Komshian, 1999) and comprehensibility (Munro and Derwing, 1995; Floccia et al, 2006; Adank et al, 2009). What also seems to have emerged from these studies is the possibility of adaptation to an accent, possibly through long-term exposure to unfamiliar accents. Several studies have set out to investigate possible adaptation to accented speech, and these will be outlined in the next section.

Evidence for Adaptation

Possible adaptation to the intelligibility of speech was shown in a study by Bradlow and Bent (2008). They investigated talker-dependent and talker-independent perceptual adaptation to foreign accented speech. They used a transcription task where listeners were required to transcribe sentences that were presented to them through headphones, and measured the accuracy of these transcriptions to see, firstly how accents affected intelligibility, and secondly whether adaptation was demonstrated. They used sentences recorded by Chinese speakers, which were rated at different levels of intelligibility (low, medium and high), and the sentences were embedded in white noise. Participants were either presented with single or multiple speakers of the accent. Experiment 1 found that participants displayed adaption to the accent in the single speaker condition, however the amount of exposure necessary was dependent on the intelligibility score of the speaker. Adaptation to speakers who were rated highly intelligible was shown after exposure to 16 sentences, adaptation to medium intelligibility speakers was shown after 32 sentences, while adaptation to low intelligibility speakers was only shown after exposure to 48 sentences (participants were exposed to 64 sentences in total, and this exposure was split into four quartiles, with differences between corresponding quartiles analysed for improvement). However, the multiple speaker condition in experiment 1 did not show improvements between quartiles (possibly because the participants were only exposed to 16 sentences of each speaker, 4 speakers in total). In experiment 2, the authors used a training regime where participants were presented with sentences produced by either a single or multiple Chinese speakers in two sessions, over two consecutive days, and were required to transcribe the sentences. After the second session, participants were then presented with two sets of 16 sentences, one produced by a Chinese speakers (post test 1) and one produced by a Slovakian speaker (post test 2), and were again required to transcribe the sentences. They found that participants who were trained with multiple speakers performed as well as on post test 1 as those in the single speaker condition who heard the same Chinese speaker in training and test phases.

The findings of this study suggests that both talker dependent and talker independent adaptation is possible within an accent, with the amount of exposure necessary for adaptation is dependent upon the number of speakers the listener is exposed to.

Evidence for adaptation of comprehensibility to a foreign accent is provided by Clarke and Garrett (2004), who used a match/mismatch task where participants heard a spoken sentence followed by a probe word on screen, which was either the same as, or different to, the last word of the sentence. Participants were required to respond as quickly as possible by pressing either the yes or no button, depending on whether the words matched or not. Sentences were chosen so that the last word of the sentence was not obvious from the rest of the sentence (e.g. "Ruth must have known about the pie"). Two foreign accents were used in this study, Spanish and Chinese, and participants heard 16 sentences of one of these accents (the accent condition). In the control conditions, participants heard 12 sentences produced in native English accent followed by 4 sentences in the foreign accent, while in the no accent condition, participants heard 16 sentences produced in native English. They found that within one minute of exposure, participants were able to adapt to the accent, and that the initial delay in processing speed was greatly reduced. The control condition appeared to rule out participants simply improving at the task, and a further experiment was carried out which added noise to the nonaccented sentences in the control group to make them harder to understand. No improvement was seen in this condition, which would also seem to rule out the possibility that participants were simply developing strategies to understand difficult speech.

Evidence for adaptation of comprehensibility to regionally accented speech has been shown in a recent study by Dahan, Drucker and Scarborough (2008). They used a speaker with an American dialect which has the effect of raising the vowel sound before /g/, but not before /k/. They then selected target word pairs where the two words are competing in the early stages of lexical competition and end with either /g/

or /k/ (e.g. "bag" and "back"). Participants would be presented with a spoken word through headphones, and their task was to select the words that they heard from one that was displayed on screen by clicking it with the mouse and moving it to a geometric shape that would be displayed next to it. Before the word was heard, a 5 X 5 grid was displayed on the screen with four words in each corner, the two target words and two filler words (with a geometric shape next to each). The spoken word was played 750 ms after the grid appeared on screen, and participant's eye movements were monitored by an eye tracker during each trial. Trials were divided into four blocks. The first block contained the words that ended with /g/, with half the participants hearing the standard vowel and the other half hearing the raised vowel. The second block contained the back-like items, and the first two blocks were then replicated in blocks three and four. They found that, for the participants presented with the accent with the raised vowel, the lexical competition between the target items had been reduced, and so they were able to select the correct response quicker. The participants were not only able to select the correct word quicker when presented with the raised vowel /g/ words, but they were also able to identify the correct response quicker for the back-like items. The authors suggest that adapting to an accent is not just simply adjusting to the speech signal that is heard but also dynamically adjusting the representations stored in the lexicon according to the speaker encountered. This was because, not only did participants react to the words where the raised vowel was present (/g/ final) words, but also to the words where the vowel remained the same (/k/ final words). In addition, the participants' eye gaze was shown to look towards the correct response quicker after they had previously been exposed to the accent, with those participants who had not been previously exposed to the raised vowel accent taking longer to select the correct response. The authors argue that because adaptation is not confined to the unusual pronunciation, the listeners overall perception of the speaker's accent has been adjusted so that word exemplars that are affected by the accent (through reduced competition) are also adapted, rather than just to specific occurrences that are directly affected by the pronunciation specific to the accent.

Further evidence for adaptation of comprehensibility to an accent can be seen in a study by Maye, Aslin and Tanenhaus (2008), which used a synthetic voice which was altered to reflect accented speech by either lowering or raising the front vowels of words (e.g. "witch" would become either "wetch" or "weech"). This had the effect of creating words that were not actually real words in standard American English, but were real words in the "new" accents. Participants were tested in two sessions, three days apart. During the first session, they were required to listen to a 20 minute story spoken in a synthetic voice (standard American accent). Following this story, participants then took part in a lexical decision task where they were presented with test stimuli (which were words presented in isolation) and required to respond whether they thought it was a real word or a made up, nonword. Participants responded by pushing a button on a button box. They were instructed to respond as quickly as possible, but not to sacrifice accuracy, and there was a two second window for responses to be made. During the second session (one to three days later) participants followed almost the identical procedure, however this time the story and lexical decision task were spoken by one of the "new" accents (lowered or raised front vowels). They found that participants, after exposure to this accent, changed their interpretations of non-words to words based on the accent that they had been exposed to, based on endorsement rates and reaction times. This study seems to demonstrate that listeners are able to adapt their speech perception systems in order to process "errors" that are a result of an accent present in the speech signal that they are attending to.

Evidence against Adaptation

Although it seems that there is evidence for adaptation of intelligibility (Bradlow and Bent, 2008) and comprehensibility (Clarke and Garrett, 2004; Dahan et al., 2008; Maye et al., 2008) to regional and foreign-accented speech, there is some evidence that suggests that adaptation is not so clear cut. Regarding intelligibility, Jongman et al.

(2003) used a training regime where trainees were presented with words spoken by a foreign accented speaker (Spanish accented English), and were required to type the word they thought they had heard on a keyboard. During the training period they received feedback as to whether they were correct or not. Before the training stage participants were tested with a different speaker of the same accent (pre test) in the same way as the training, except they did not receive any feedback. Following the completion of the training phase, participants were tested again (post test) in the same way as the pre test, and the results of the pre and post tests were analysed to see whether there was any improvement in accuracy. To evaluate whether training was beneficial, control participants took part in the pre and post test, but not the training phase. They found that the training regime did not produce any advantage in the perception of Spanish-accented words compared with the control participants, although they did find evidence for advantages in exposure to speaker specific information.

Adank and McQueen (2007) also investigated possible adaptation of comprehensibility to accented speech, although they used regional as opposed to foreign accented speech. First they presented participants with an animacy task, where spoken words were presented to them, and they were required to decide if the word they heard related to a living or a non-living entity. Words were spoken in both a familiar regional accent (the area they lived in) and an unfamiliar regional accent. This task demonstrated that there was a processing cost associated with the unfamiliar accent used in this study. Next, to investigate whether exposure to the accent would lead to short term adaptation, participants were presented with approximately 20 minutes of speech in either the familiar or unfamiliar regional accent. This speech was made up of a series of sentences and, as a distracter task, participants had to decide whether the subject of the sentence was singular or plural. Following this learning phase, participants were again presented with the animacy task that preceded the learning phase. The authors did not however find any evidence of adaptation to the unfamiliar

accent, suggesting that exposure in this way was not sufficient for adaptation to occur. They ensured that adaptation was talker independent by using test speakers that were not used in the learning phase, so it is not clear whether talker specific adaptation would have occurred using this method.
Floccia et al. (2009b) also attempted to induce comprehensibility adaptation to accents in a similar way to Clarke and Garrett (2004). However, instead of a cross-modal matching task, they used a lexical decision task where participants heard spoken sentences and had to decide if the last word they heard was a real word or a made up non-word. English-speaking participants were presented with different regional (Irish) and foreign (French) accents, as well as with their own, familiar, regional accent (Plymouth). In a series of experiments, participants were either presented with blocks of sentences in sequence (i.e. Plymouth, then French accents) or were presented with all accents randomly (to control for "surprise" effects when presented with a new accent). The results showed that there was a processing cost involved with both the regional and foreign accents, and also that, in contrast to the Clarke and Garrett study, no evidence of adaptation to accents was shown within the laboratory setting.

In summary, what is apparent in the literature is that there is a cost associated with the processing of accented speech (Munro and Derwing, 1995; Schmid and Yemi-Komshian, 1999; Floccia et al., 2006; Adank et al., 2009). What is less clear is our ability to adapt to this accented speech. It could be that adaptation to an accent does not improve both intelligibility and comprehensibility of speech. It would seem that the majority of studies that have found no evidence of adaptation have investigated comprehensibility (Adank and McQueen, 2007; Floccia et al., 2009b; but see Dahan et al., 2008), so perhaps it is only the intelligibility of speech that improves through adaptation (Bradlow and Bent, 2008). However, the results of the Clarke and Garrett (2004) study seem to suggest that comprehensibility does in fact improve with adaptation (although Floccia et al., 2009b, did not find any evidence of adaptation with a comparable method), as does the Maye et al. (2008) study (although this study used an artificial, synthetic accent, rather than a real regional or foreign accent). Therefore previous studies fail to provide clear cut evidence as to whether comprehensibility can improve through adaptation to an accent.

One possible explanation for these inconsistencies could lie in the mechanisms of the adaptation process. It is possible that adaptation to an accent would occur because information about the accent has been encoded into memory. Therefore, the next time the accent is encountered, this information is available so the accent can be processed more efficiently. It could also be that some form of filter has been built up which allows our perceptual system to process accented speech better. If we have built up a memory representation, or an accent filter due to long term exposure, then one would expect to find evidence that presumably familiar accents cause less perturbation, therefore more adaptation, than unfamiliar ones. Previous studies have demonstrated the detrimental effect of dialects on speech processing (Adank and McQueen, 2007; Adank et al., 2009; Floccia et al., 2006; Maye et al., 2008), without necessarily contrasting familiar and unfamiliar accents. The first set of studies (Experiments 1 to 4) will examine effects of accent familiarity on short-term and long-term adaptation. The first hypothesis deals with the effect of familiarity in the observation of accent-related speech processing impairment: is that the case that presumably familiar accents would elicit less initial impairment than unfamiliar ones, suggesting that long term adaptation has occurred? This will be tested by measuring lexical decision with foreign accents varying on familiarity. The second hypothesis deals with short-term exposure and its impact on adaptation mechanisms. It is not clear from the literature whether comprehensibility of accented speech can adapt with short exposure to unfamiliar accent. This issue will be examined by searching for traces of short-term adaptation in a lexical decision task, especially looking for this adaptation in unfamiliar accents. The third hypothesis deals with the robustness of short-term adaptation in the long term: can learning on a particular accent be still evidenced after a long delay? The very existence of familiarity effects, if proven to be true, would suggest that we can retain some adaptation mechanisms for previously encountered accents. This question will be examined by re-measuring lexical decision to accented speech one week after the first session.

Considering accent normalisation as a whole, the nature of the initial lexical processing cost associated with accent presentation raises some interesting points. As previously discussed, some models of lexical access suggest some form of matching the input signal to an abstract stored representation of the word that is being searched for (Pallier et al., 2001). This would suggest some form of normalisation process when dealing with accented speech, which begs the question of why this process leads to perturbation when faced with an unfamiliar accent. Is it caused by a temporary slowing of prelexical processing, by a lowering down of word activation levels in the lexicon, or to the intervention of a guessing top-down mechanism? To investigate this, Experiments 5 to 7 will use a cross-modal matching task, where participants are presented with a spoken sentence, followed by a word displayed on screen, and they will be required to decide whether the final word heard in the sentence is the same as the word displayed on screen. The spoken sentences will be presented in a number of different accents to investigate whether the presence of these accents will affect the speed with which participants respond. Then, in order to investigate whether the processing cost is caused by a temporary normalisation process that takes place before lexical access, a delay will be introduced between the end of the spoken sentence and the presentation of the word visually. If this is the case, any processing cost related to accents should not be evident in the delayed response condition. If this processing cost is caused by delay in lexical activation per se, and/or slowing down of lexical access, and/or reduced lexical activation, then it could still be evidenced even in a response delayed condition.

Chapter 2

Short term and long term adaptation to accents

In this chapter, four experiments will be presented examining the effects of accent familiarity on short-term and long-term adaptation in adult listeners. To determine whether accent-related initial impairment relates to accent familiarity, reaction times in a lexical decision task will be compared for different levels of foreign accent familiarity (Experiments 1 and 4). These experiments will also look for evidence of short-term (Experiments 1 to 4) and long-term (Experiment 1) adaptation of accent comprehensibility.

Experiment 1: Effect of accent familiarity in the short and long term

This experiment opposes familiar and unfamiliar foreign accents, and examines whether exposure in laboratory conditions can lead to short-term and long-term adaptation. Participants will be required to perform a lexical decision task on words produced in a given foreign accent, and will be tested on the same accent and a different accent one week later. If listeners can adapt in the short term, then faster reaction times should be obtained during the course of the experiment in week one. If listeners can adapt in the long-term to accents, then faster reaction times in week two for the accent which has been presented in week one are expected, as compared with the new accent. Furthermore, an effect of accent familiarity should emerge, as the most familiar accent should elicit faster reaction times than the less familiar one, in week one and in week two, as a result of long term exposure to that accent over a lifetime. Words and nonwords will be presented at the end of sentences (e.g. "he was late getting home because he ate the last toffees", "the road was closed because there had been a recent bahal") modelled upon the studies of Floccia et al. (2006) and Floccia et al. (2009b). With this paradigm, the typical result is a delay in word identification for regional or foreign accents as compared with the home accent. However, this experiment is not interested in the comparison between a foreign accent and the home accent per se, but rather in the modulation of the accent effect as a function of duration of exposure.

Participants

Fifty-five participants (29 males) with an average age of 24.1 years took part in this study. Participants were monolingual native English speakers originating from the South West of England recruited from the University of Plymouth, and participants were either granted a credit as part of their course requirements, or were recruited using the University's paid participants pool, and were paid £3 for participating. All participants reported that they had normal hearing abilities. In order to establish the relative familiarity of the participants with the accents used in this experiment, all participants reported that they had not been particularly exposed to either of the accents (such as through friends or family members). This, together with the fact that they originated from the South West of England, suggests that they were had not been regularly exposed to either accent. Participant's familiarity with the accents was therefore based on the more likely exposure to French accents through other sources, such as the media, whereas it was thought that the participants would be less likely to be exposed to Malaysian accents in this way. These selection criteria are the same for all adult studies, and therefore will not be repeated hereafter.

Participants were split into two conditions, 28 were in the familiar (French) accent group and 27 were in the unfamiliar (Malaysian) foreign accent group.

Stimuli

Sentences were constructed so that they were similar in length and number of syllables. Each sentence ended with either a real word or a made up, but phonologically possible non-word. All words selected were bi-syllabic, trochaic (stressed on their first syllable) noun words generated using the English Lexicon Project website (Balota, Yap, Cortese, Hutchison, Kessler, Loftis, Neely, Nelson, Simpson and Treiman, 2007). Selected words had similar frequency characteristics and number of phonological neighbours, as these factors can affect lexical decision reaction times, and these parameters were used to control for this. The real words used were selected so that they could not be easily identified from the rest of the sentence (for sentences, see appendix). Non-words were generated using the English Lexicon Project website (Balota et al., 2007), and were selected based on similar number of phonological neighbours (frequency was not applicable as these were not real words) to control for effect on lexical decision reaction times (for the list of words, non-words and sentences, see appendix A).

Several different speakers were used to record the stimuli. There were three Plymouth accented speakers (speaker one, aged 40; speaker two, aged 38; speaker three, aged 40; all three speakers born and raised in Plymouth), two French accented speakers (speaker one, aged 35, born and raised in Paris, in Plymouth for 12 years; speaker two, aged 39, born and raised in Grenoble with a standard French accent, in Plymouth for three years), and two Malaysian accented speakers (speaker one, aged 24, born and raised in Malaysia, in Plymouth for three years; speaker two, aged 21, born and raised in Malaysia, in Plymouth for one year). For control purposes, all speakers were female to try to minimise differences between speakers of the same accent (for a complete list of speakers used in Experiments 1 to 7, see appendix C).

In order to ascertain the perceived strength of the accents of the speakers compared to each other, a separate group of 10 participants from the South West were randomly presented with the recordings of the speakers (five sentences per speaker). After each sentence, the origins of the speaker was displayed on the screen (Plymouth, Malaysian, etc.) and listeners were then asked to rate how strong the accent was on a scale of one to four, with one being "no accent" and four being "very strong accent" (all the speakers used in Experiments 1 to 7 were rated in this way, but only the speakers relevant to this experiment will be presented here, when a new speaker is introduced in subsequent experiments the corresponding rating results will be presented). To rate the Plymouth accent, by convention listeners were asked to give a 4 if the speaker sounded very familiar (therefore having a strong accent) and 1 if the speaker did not sound like originating from Plymouth. A paired samples T-test was carried out on these data, with pair comparisons between speakers of the same accent. On average, the Plymouth accented sentences were rated at 2.59, the French accented sentences at 3.32 and the Malaysian accented sentences at 2.61. There was a significant effect of accent overall, $F1(2,18) = 9.12$, $p < .01$, $\eta^2 = .51$, and there was also an effect of accent between Plymouth and French, $F1(1,9) = 13.21$, $p < .01$, $\eta^2 = .6$, and between French and Malaysian, $F1(1,9) = 22.36$, $p < .01$, $\eta^2 = .71$. There was no effect of accent between Plymouth and Malaysian, $F1(1,9) < 1$. For the Plymouth speakers, the average rating for speaker PL1 (1.92) was significantly lower than for speaker PL2 (2.32), $t = 2.68$, $df = 9$, $p < .05$. The 95% confidence interval was -.73 to -.06, and the effect size was .69. For the French speakers, the average rating for speaker F1 (3.06) was significantly lower than for speaker F2 (3.58), $t = 3.12$, $df = 9$, $p < .05$. The 95% confidence interval was -.89 to -.14, and the effect size was 1.13. For the Malaysian speakers, the average rating for speaker M1 (1.5) was significantly lower than for speaker M2 (3.72), $t = 16.07$, $df = 9$, $p < .001$. The 95% confidence interval was -2.53 to -1.91, and the effect size was 6.85.

There were several different blocks of sentences used in this study. Each block was made up of 15 sentences in total, 10 sentences ending in a word and five sentences ending in a non-word. Each Plymouth accented speaker recorded one block of sentences. The French and Malaysian accented speakers recorded two blocks each. The speakers from the same language background recorded the same two blocks, but different from the two blocks recorded by the other speakers. Figure 1 shows how these blocks were presented to the participants in each condition.

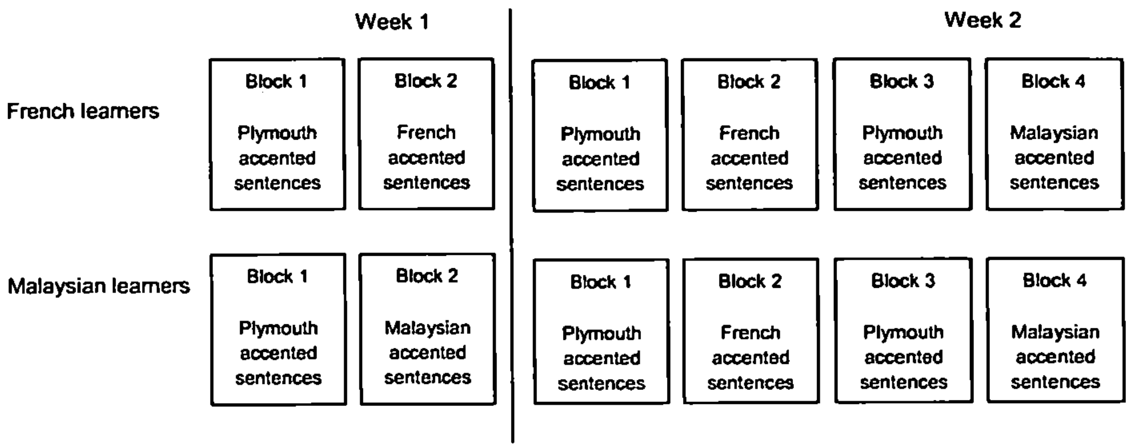

Figure 1: What blocks of sentences participants heard in week one and week two, broken down between conditions.

Blocks two and four were counterbalanced so half participants were presented with French in block two and Malaysian in block four (as shown in Figure 1), while the other half were presented with Malaysian in block two and French in block four.

Procedure

The experiment was controlled using a script created using E-prime. Each participant took part in two testing sessions, one week apart. During both sessions the stimuli were presented to participants through headphones whilst seated at an individual workstation. The participants were required to perform a lexical decision task, where they would listen to a series of sentences and they had to decide whether the last word of the sentence was a real word or a made up word. Participants responded by pressing the appropriate key on the keyboard, and, because this was a reaction time study, they were instructed to respond as quickly as possible to each sentence. Instructions were presented on screen. Participants had three seconds in which to make a response. Once a response was made, or the time limit was up, feedback was presented on screen, which consisted of either "correct", "incorrect" (with a reminder of which key related to which response), or "no response" (again with a reminder as to which key related to which response). Two keys on the keyboard were used for responses, "A" and "L". Participants used their dominant hand for a "word" response, and their weak hand for a "nonword" response. Therefore, if a right-handed participant decides that the last word heard was a real word, they would press "L", and if they decided it was a nonword, they would press "A". The keys are therefore reversed for left-handed participants, "A" = word, "L" = nonword.

During the first session, sentences were presented in two stages. The first stage was a training stage, where participants were presented with eight sentences spoken in a Received Pronunciation (RP) accent. This was to familiarise the participants with the task. The second stage consisted of two blocks of 15 sentences each. The first block was spoken by a Plymouth accented speaker (all participants heard the same speaker during this block). This block acted as the baseline measure, as this was the home accent for the participants, and this was used as a comparison to the foreign accent block. The second block was the foreign accent block. Participants were split into two groups, French learners and Malaysian learners, and each participant heard a speaker from the relevant language background. Within each group, half heard one speaker while the other half heard the other (i.e., in the French learners, half heard speaker F1, while the other half heard speaker F2). All participants heard the same sentences spoken by different speakers. After each response, feedback was displayed on the screen.

During the second session, which took place one week later, there was no training stage. This time, all participants were presented with four blocks of sentences. The first block was spoken by a second Plymouth accented speaker, and the second block was spoken by a foreign accented speaker (counterbalanced across participants whether this was a French or Malaysian speaker). The third block was spoken by the third Plymouth accented speaker while the final block was spoken by a speaker of the foreign accent that was not presented in block two. In this way all participants completed all conditions during the second session (previously encountered accent, new accent and baseline). Within all blocks, presentation of sentences was randomised for each participant. To control for the participants simply remembering the sentences from the first session, new sentences were constructed and recorded for week two, in the same way as the sentences used in week one were constructed and recorded.

Results

Week one

Out of 2090 expected responses, 214 were excluded. These were for incorrect or no response, responses under 200ms or over 2000ms, and all responses under or over 2.5 times the standard deviation of the mean of each participant. Broken down between conditions, 85 of these errors were in the familiar (French) accent group, and 129 were in the unfamiliar (Malaysian) accent group. The error scores were analysed to see if there was any differences between the two groups, and between the Plymouth accent and foreign accent blocks, and these can be seen in Table 1.

Table 1: *Mean percentage error scores and standard deviations between experimental blocks in week 1, broken down into groups.*

	Plymouth accent block		Foreign accent block	
	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation
French learners	3.57	4.96	13.81	8.5
Malaysian learners	2.96	3.38	26.17	19.03

The error scores were analysed used a repeated measures ANOVA, with one within-participant variable; block (baseline and foreign), and one between-participants variable; group (French learners and Malaysian learners). There was a significant effect of block, $F1(1,53) = 76.5$, $p < .001$, $\eta^2 = .59$, where the percentage of error rates were higher for the foreign accent block compared with the Plymouth accent block. There was a significant effect of group, $F1(1,53) = 7.19$, $p < .05$, $\eta^2 = .12$, where error rates in the foreign accent block were higher for the Malaysian learners compared with the French learners, and there was a significant interaction between block and group, $F1(1,53) = 11.51$, $p < .01$, $\eta^2 = .18$. This suggests that the foreign accent sentences were more difficult to comprehend, and so resulted in more errors, than the Plymouth accented sentences, and also that the Malaysian accented sentences were more difficult to comprehend than the French accented sentences.

Figure 2 shows the mean reaction times for the two experimental blocks between the two groups in week one.

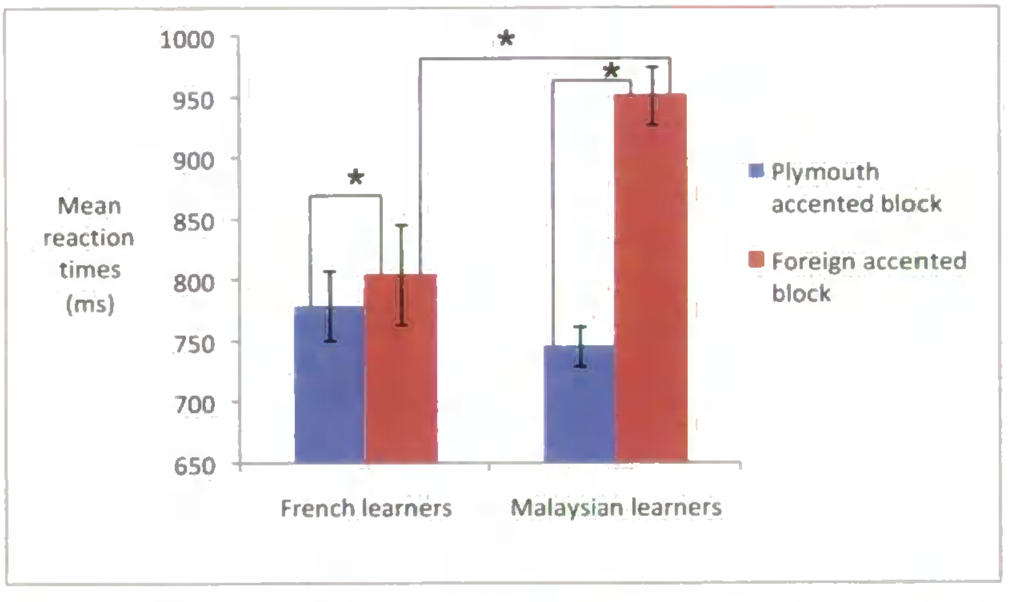

Figure 2: Mean reaction times (RT) between experimental blocks in week one, broken down into groups.

Reaction times were recorded for each response, and these were examined using an analysis of variance (ANOVA) with two within-participant variables; block (baseline and foreign) and words (word or non-word), and two between-participant variables; group (French learners and Malaysian learners) and speaker (speaker one and speaker two). There was a significant main effect of block, $F1(1,51) = 53.15$, $p < .001$, $\eta^2 = .51$,

$F2(1,26) = 32.59$, $p < .01$, $\eta^2 = .56$, where reaction times in block two were higher than reaction times in block one (block one average – 771.54, block two average – 884.83). There was no main effect of group by participant, $F1(1,51) = 2.78$, $p = .1$, $\eta^2 = .05$, but there was by item, $F2(1,26) = 6.57$, $p < .05$, $\eta^2 = .2$ (French group average – 797.69, Malaysian group average – 858.68). There was a significant effect of words, $F1(1,51) = 4.77$, $p < .05$, $\eta^2 = .09$, $F2(1,26) = 5.65$, $p < .05$, $\eta^2 = .18$, where reaction times were faster to words than to non-words, which is expected, as words should be responded to quicker than non-words (Forster and Chambers, 1973) (words average – 810.8, nonwords average – 845.6).

As can be seen on Figure 2, there is a significant interaction overall between blocks and groups, $F1(1,51) = 37.86$, $p < .001$, $\eta^2 = .51$, $F2(1,26) = 18.9$, $p < .001$, $\eta^2 = .42$. There was no difference on the baseline (block one) between the groups, $F1(1,53) < 1$, $F2(1,26) = 2.17$, $p = .15$, $\eta^2 = .08$ (French group average – 779.2, Malaysian group average – 745.9), but there was a significant difference on block two between the groups, $F1(1,53) = 9.34$, $p < .01$, $\eta^2 = .15$, $F2(1,26) = 18.15$, $p < .001$, $\eta^2 = .41$, where mean reaction times were higher for the Malaysian group than for the French group (French group average – 805.3, Malaysian group average – 951.4).

Effect of speaker

In order to ascertain whether there was a general accent effect or whether different speakers within an accent had any effect, the data was broken down between the two speakers of each accent within the experimental conditions, as shown in Figure 3. It would seem that there was a large difference between the two speakers in the Malaysian group, with speaker two seemingly showing much slower reaction times than speaker one. However, Malaysian speaker one stills seems to show slower reaction times compared with the French speakers, and the difference between performance on the baseline and Malaysian speaker one seems greater than the same comparison for the French speakers.

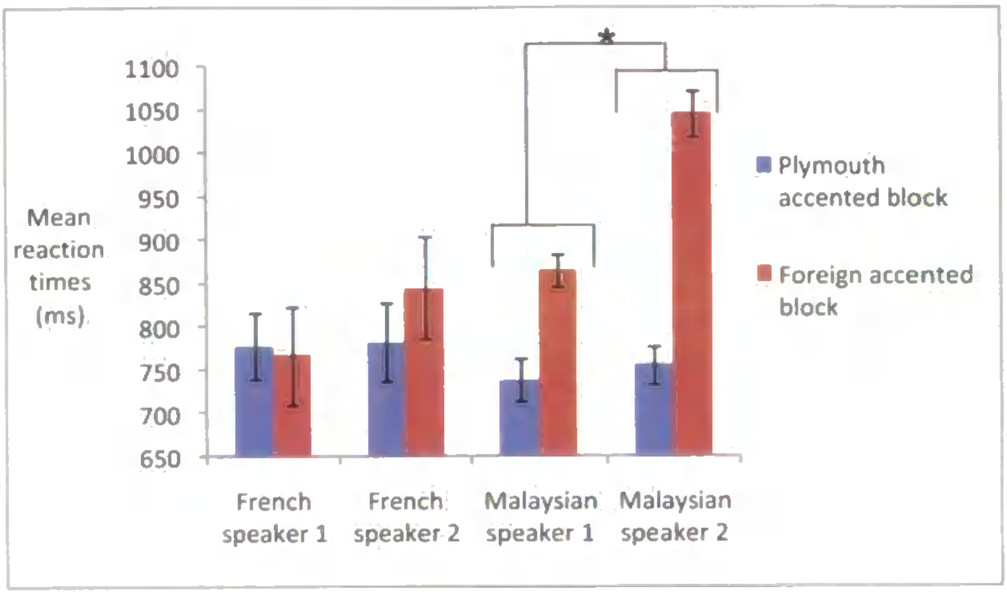

Figure 3: Mean reaction times for the two experimental blocks, broken down between groups and speakers.

For the French group, there was no effect of speaker heard, $F1(1,26) < 1$, $F2(1,28) = 2.76$, $p = .11$, $\eta^2 = .09$, and no interaction between block and speaker, $F1(1,26) = 3.39$, $p = .08$, $\eta^2 = .12$, $F2(1,28) = 3.44$, $p = .07$, $\eta^2 = .11$. For the Malaysian group, there was a significant effect of speaker heard, $F1(1,25) = 13.53$, $p < .01$, $\eta^2 = .35$, $F2(1,28) = 24.64$, $p < .001$, $\eta^2 = .47$, and there was a significant interaction between block and speaker, $F1(1,25) = 17.97$, $p < .001$, $\eta^2 = .42$, $F2(1,28) = 15.56$, $p < .001$, $\eta^2 = .36$. As commented upon above, Figure 3 shows that there seems to be an effect of accent for Malaysian speaker one, and in fact there is a significant effect of block for this speaker, $F1(1,13) = 16.1$, $p < .01$, $\eta^2 = .55$, $F2(1,28) = 75.41$, $p < .001$, $\eta^2 = .73$ (Plymouth block average – 746.0, Foreign accent block average – 864.4).

However, there is no significant difference between the French learners and Malaysian speaker one on the foreign accent block, $F1(1,40) < 1$ (French speakers average – 805.3, Malaysian speaker one average – 864.82). Looking at each French speaker separately compared to Malaysian speaker one, there is a significant interaction between block and speaker for speakers F1 and M1, $F1(1,26) = 11.78$, $p < .01$, $\eta^2 =$

.24, and there is no interaction between block and speaker for speakers F2 and M1, $F1(1,26) = 2.38$, $p = .14$, $\eta^2 = .08$.

The results of week one show that participants performed worse with Malaysian accented speech than with the French accented speech, as predicted by the accent familiarity hypothesis, but this seemed to be mainly due to one Malaysian speaker out of two, even though reaction times for the second speaker also showed a trend in that direction.

These main block analyses were useful to look for a familiarity effect in accent processing, presumably due to long-term exposure. In what follows, the possible short-term effects of accent exposure will be examined to see whether any adaptation had occurred within the experimental blocks. The average of the first and last three sentences in each block were calculated and analysed, and are shown in Figure 4. Indeed, following Clarke and Garrett (2004) and Floccia et al. (2009), it appears that reaction to an unexpected accent change can result in a very temporary perturbation of reaction times, that could resume after three or four sentences.

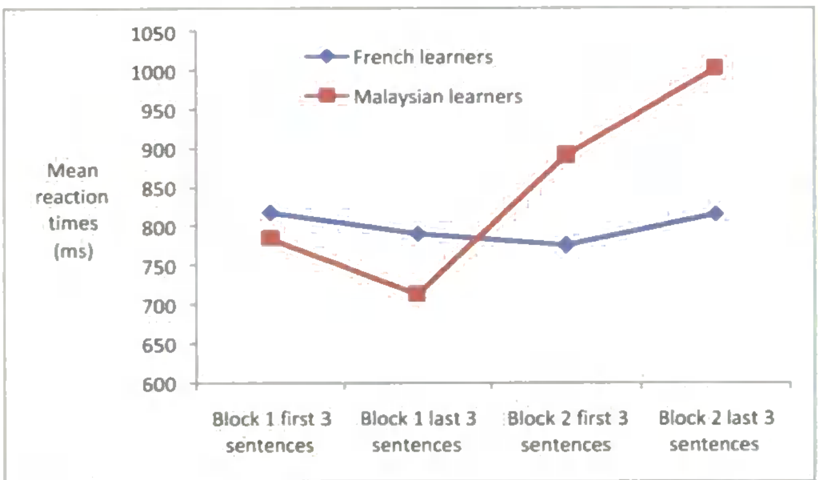

Figure 4: Mean reaction times to the first and last three sentences heard within each experimental block, broken down into groups.

It would seem from Figure 4 that participants in both groups seem to improve within the Plymouth accent block as reaction times seem to be quicker for the last three sentences heard compared with the first three sentences heard. Participants in the French accent group do not seem to show much difference between the end of the Plymouth block and the beginning of the foreign accent block, and in fact seem to improve slightly, whereas participants in the Malaysian accent group seem to show a dramatic increase in reaction times at the end of the foreign accent block. Reaction times for both groups in the foreign accent block seem to increase by the end of the block, with participants in the Malaysian group showing a greater increase than the French group.

A repeated measures ANOVA was carried out with two within participant variables; block (baseline and foreign accent) and sentences (first three and last three), and two between participant variables; group (French learners or Malaysian learners) and speaker (speaker one or speaker two). There was a significant interaction between block and sentences, $F1(1,50) = 13.87$, $p < .001$, $\eta^2 = .22$, and no interaction between block, sentences and group, $F1(1,50) = 2.84$, $p = .1$, $\eta^2 =.05$. For block one only, there was no interaction between sentences and group, $F1(1,51) = 1.16$, $p = .29$, $\eta^2 = .02$. For block two only, there was no interaction between sentences and groups, $F1(1,51) = 2.38$, $p = .13$, $\eta^2 = .05$.

Looking at both groups separately, for the French learners there was no significant effect of sentences in the baseline block, $F1(1,26) = 1.18$, $p = .29$, $\eta^2 = .04$ (first three sentences average – 818.1, last three sentences average – 791), and no significant effect of sentences in the foreign accent block, $F1(1,26) = 1.33$, $p = .36$, $\eta^2 = .05$ (first three sentences average – 774.8, last three sentences average – 815.2). For the Malaysian learners, there was a significant effect of sentences in the baseline block, $F1(1,25) = 4.56$, $p < .05$, $\eta^2 = .15$ (where reaction times were quicker to the last three sentences compared with the first three sentences, first three sentences average –

785, last three sentences average – 713), and there was a significant effect of sentences in the foreign accent block, $F1(1,25) = 13.9$, $p < .01$, $\eta^2 = .36$ (where reaction times were quicker in the first three sentences compared with the last three sentences, first three sentences average – 890.3, last three sentences average – 1002).

In summary, in week one an effect of familiarity was found over the entire experimental block, showing that participants were faster to process the French accent than the presumably less familiar Malaysian, although statistically this was mainly due to one Malaysian speaker out of two. It was also found that within the experimental block, Malaysian learners' reaction times slowed down over time as compared with French learners, as if participants were engaging more and more resources to process and encode this unusual accent. Again it is possible that this effect could be due to one of the Malaysian speakers. However, Figure 5 shows that participant's reaction times to both Malaysian speakers in block two are slower for the last three sentences compared with the first three sentences.

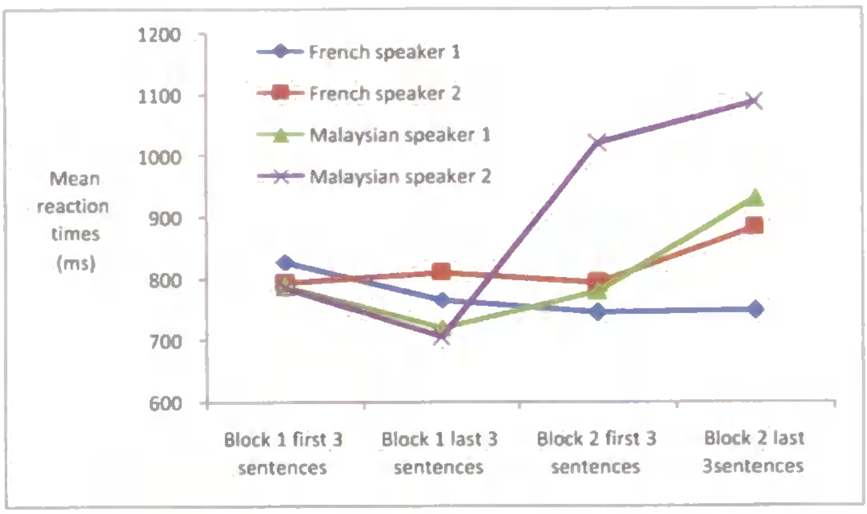

Figure 5: Mean reaction times to the first and last three sentences heard within each experimental block, broken down into groups and speakers.

Week two

Out of 2820 expected responses, 146 were excluded. These were for incorrect or no response, responses under 200ms or over 2000ms, and all responses under or over 2.5 times the standard deviation of the mean of each participant. Broken down between conditions (accent heard in week one), 70 incorrect responses were in the familiar (French) accent group and 76 were in the unfamiliar (Malaysian) accent group. The error scores were analysed to see if there was any differences between the two groups, and between the Plymouth accent and foreign accent blocks, and these can be seen in Table 2.

Table 2: *Mean percentage error scores and standard deviations between experimental blocks in week 2, broken down into groups.*

	Plymouth accent block		French accent block		Malaysian accent block	
	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation
French learners	3.89	4.68	4.17	5.49	7.22	8.55
Malaysian learners	4.34	3.82	4.35	6.23	8.99	14.85

The error scores were analysed using a repeated measures ANOVA, with one within-participant variable; block (baseline, French and Malaysian), and one between-participant variable; group (French learners and Malaysian learners). There was a significant effect of block, $F1(2,90) = 3.42$, $p < .5$, $\eta^2 = .07$, where error scores were higher for the Malaysian accent block compared with the Plymouth and French accent blocks. There was no difference between the two groups, $F1(1,45) < 1$, and no interaction between block and group, $F1(2,90) < 1$. This suggests that the two groups did not differ on their comprehension of the different accent blocks.

Figure 6 shows the mean reaction times for each experimental block, between the two groups.

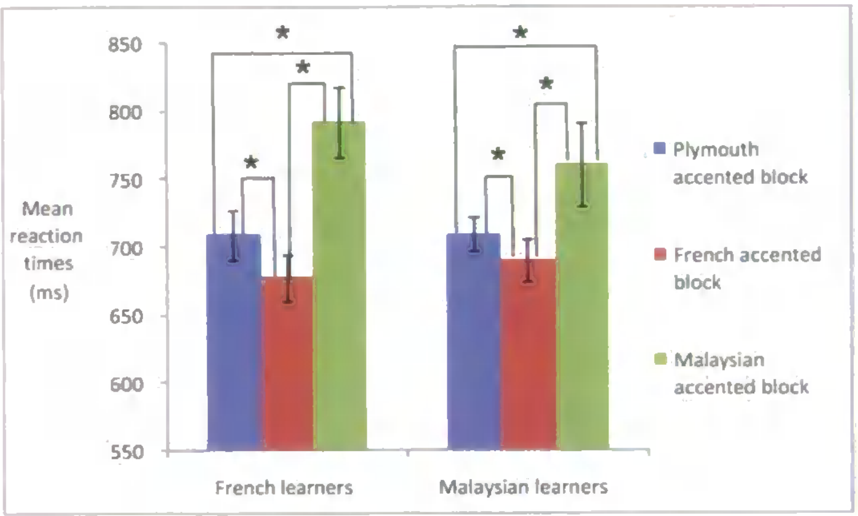

Figure 6: Mean RT's between experimental blocks in week two, broken down into groups.

Two baseline blocks were used during week two so that, following the first foreign accent block, participants would return to their normal processing speed before the second foreign accent block. The two baseline blocks have been merged together to give an average reaction time to one single baseline condition.

Reaction times were analysed using a repeated measures ANOVA with two within-participants variables; block (baseline, French, Malaysian) and words (word or non-word), and two between-participant variables; group (French learners and Malaysian learners) and speakers (speaker one and speaker two). There was a significant effect of block, $F1(2,84) = 22.84$, $p < .001$, $\eta^2 = .35$, $F2(2,56) = 19.86$, $p < .001$, $\eta^2 = .42$, where reaction times were quickest to the French accent, followed by reaction times to the baseline and slowest reaction times to the Malaysian accent (baseline average – 707.87, French accent average – 689.96, Malaysian accent average – 779.72). It should be noted here that sentences heard during the baseline and the next blocks are all different, which means that they can lead to slower reaction times, even though they are produced in the participants' most familiar accent. Of interest is not the transition from baseline to the next blocks, but the modulation of these transitions across accent conditions.

There was a significant effect of words, $F1(1,42) = 37.45$, $p < .001$, $\eta^2 = .47$, where words are reacted to quicker than nonwords (words average – 708.8, nonwords average – 742.9), and there was no main significant difference between the two groups, $F1(1,44) < 1$, $F2(1,28) < 1$ (French learners average – 731.9, Malaysian learners average – 719.8).

There was no significant interaction between blocks and group, $F1(2,84) = 1.35$, $p = .27$, $\eta^2 = .03$, $F2(2,56) = 2.42$, $p = .1$, $\eta^2 = .08$. There was no significant interaction between blocks (baseline, French) and groups, $F1(1,42) = 2.12$, $p = .15$, $\eta^2 = .04$, $F2(1,28) < 1$, or between blocks (baseline, Malaysian) and groups, $F1(1,42) < 1$, $F2(1,28) = 2$, $p = .17$, $\eta^2 = .07$. The interaction between blocks (French, Malaysian) and groups was not significant by participant, $F1(1,42) = 1.66$, $p = .21$, $\eta^2 = .04$, but was significant by item, $F2(1,28) = 11.21$, $p < .01$, $\eta^2 = .27$.

There was no difference on the baseline between the groups, $F1(1, 45) < 1$, $F2(1,28) < 1$, no difference on the French block between the groups, $F1(1,45) < 1$, $F2(1,28) < 1$, and there was no difference on the Malaysian block between the groups by participant, $F1(1,45) <1$, but there was by item, $F2(1,28) = 6.26$, $P < .05$, $\eta^2 = .18$.
In summary, participants did seem to benefit from having been exposed to a particular accent in week one, as Figure 6 shows a tendency for Malaysian learners to be faster with Malaysian in week two as compared with the French learners. This trend is only confirmed by a by-item significant interaction between blocks (French vs. Malaysian) and groups (see above).

Week one and week two

Reaction times were compared between the two weeks. Baseline values between the two weeks were compared first, and are shown in Figure 7. As shown on the graph, it would appear that reaction times were quicker during week two compared with week one.

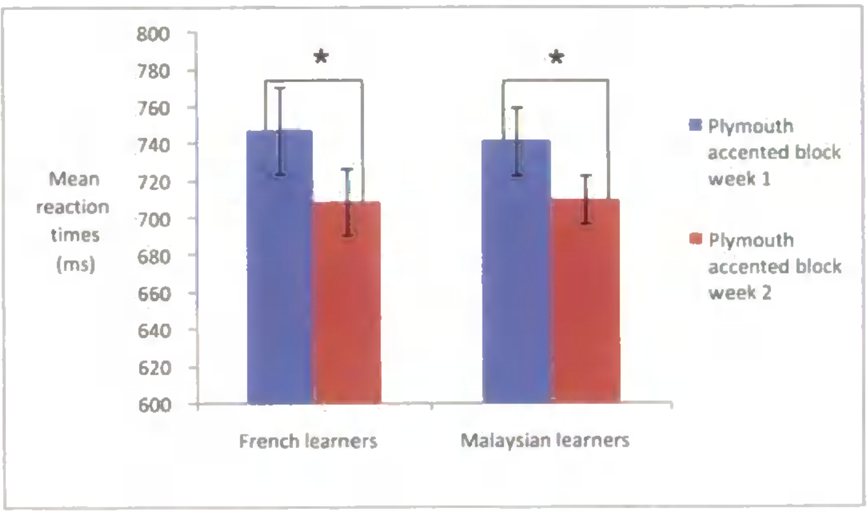

Figure 7: Average reaction times to the baseline blocks between weeks one and two, broken down between conditions.

Baseline values were analysed using a repeated measures ANOVA, with one within participant variable; week (week one and week two), and one between participant variable; group (French learners and Malaysian learners). There was a significant effect of week on the baseline, $F1(1,45) = 11.15$, $p < .01$, $\eta^2 = .2$, $F2(1,43) = 5.28$, $p < .05$, $\eta^2 = .11$, where reaction times were quicker to the baseline in week two (week one baseline average – 744.3, week two baseline average – 709.3). There was no main effect of group by participant, $F1(1,45) < 1$, but there was by item, $F2(1,43) = 15.52$, $p < .001$, $\eta^2 = .27$, and no interaction between baseline and group by participant, $F1(1,45) < 1$, but there was by item, $F2(1,43) = 14.43$, $p < .001$, $\eta^2 = .25$. This suggests that all participants had improved in the task between week one and week two (although sentences and words are different between the two weeks, so it is difficult to conclude). It mainly shows that they were all comparable across groups.

Reaction times to the foreign accent blocks were then compared. Firstly reaction times to the foreign accent block in week one and reaction times to the same foreign accent block in week two (i.e. French week one v. French week two, Malaysian week one v. Malaysian week two) were compared as shown in Figure 8. As shown on the graph, participants seem to have improved in week two, where reaction times appear quicker compared with week one. However, again the sentences are different between week one and week two, so this must be interpreted cautiously. What is more important is whether the improvement is of the same magnitude for French and Malaysian learners.

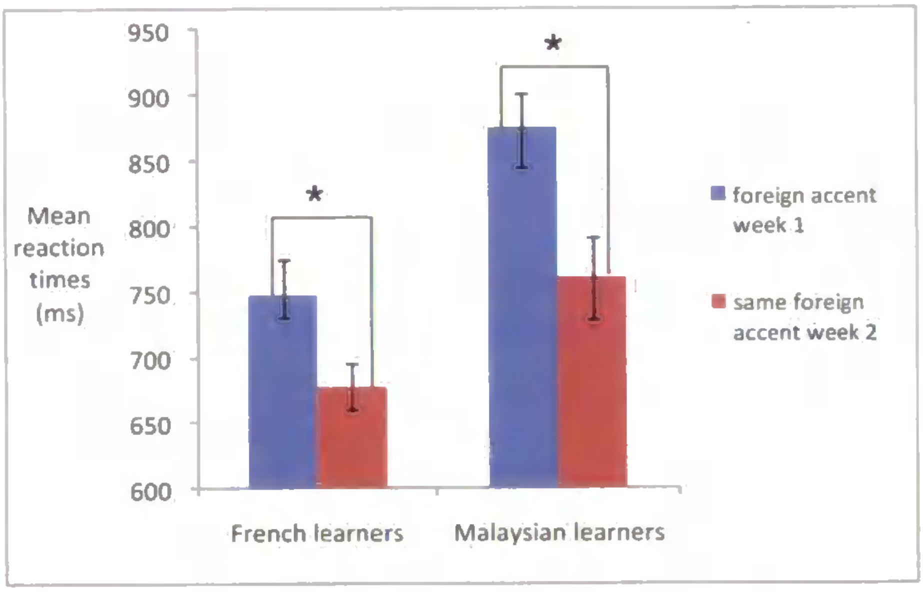

Figure 8: Average reaction times to the foreign accent block in week one and the same foreign accent block in week two, broken down between conditions.

Reaction times were analysed using a repeated measures ANOVA, with one within participant variable; week (week one foreign accent block and week two same foreign accent block), and one between participant variable; group (French learners and Malaysian learners). There was a significant effect of week, $F1(1, 45) = 20.78$, $p < .001$, $\eta^2 = .32$, $F2(1,28) = 53.55$, $p < .001$, $\eta^2 = .66$, where reactions times were quicker in week two (week one foreign accent block average – 811.3, week two same foreign accent block average – 719.1). There was a significant main effect of group, $F1(1,45) = 12.36$, $p < .001$, $\eta^2 = .22$, $F2(1,28) = 79.82$, $p < .01$, $\eta^2 = .74$, where reaction times were quicker in the French learners group (French learners average – 712.4, Malaysian learners average – 818.1), and there was no interaction between week and group by participant , $F1(1, 45) = 1.26$, $p = .27$, $\eta^2 = .03$, but there was by item, $F2(1,28) = 9.67$, $p < .01$, $\eta^2 = .26$. These analyses do not mean much, except for the interaction between weeks by item, which suggests that there is an improvement in week two for some sentences. However, as sentences are not repeated from one week to the next, this means that some sentences in week two are less "French", or less "Malaysian" than sentences in week one.

Next, in order to see whether learning due to exposure to a given accent could transfer to another accent, reaction times were compared between the accent not heard during the first week (i.e. French week one v. Malaysian week two, Malaysian week one v. French week two), as shown in Figure 9.

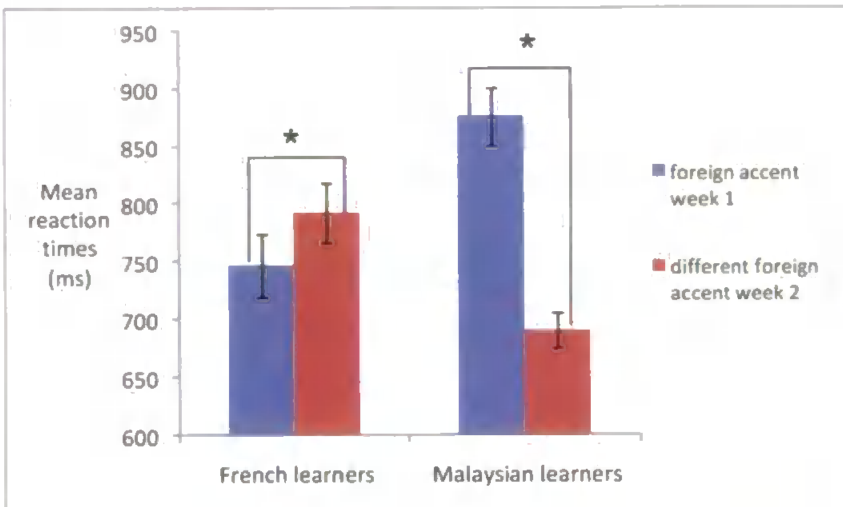

Figure 9: Average reaction times to the foreign accent block in week one and different foreign accent block in week two, broken down between conditions.

Reaction times were analysed using a repeated measures ANOVA, with one within participant variable; week (week one foreign accent block and week two different foreign accent block). There was a significant effect of week, $F1(1, 45) = 18.02$, $p < .001$, $\eta^2 = .29$, $F2(1,28) = 35.89$, $p < .001$, $\eta^2 = .56$, where reaction times were quicker in week two (week one foreign accent block average – 811.3, week two different foreign accent block average – 741.1). There was no significant difference between the two groups, $F1(1, 45) < 1$, $F2(1,28) = 3.71$, $p = .06$, $\eta^2 = .12$, but there was a significant interaction between week and group, $F1(1,45) = 48.75$, $p < .001$, $\eta^2 = .52$, $F2(1,28) = 124.58$, $p < .001$, $\eta^2 = .82$ This interaction suggests that French learners were better with Malaysian in week two than Malaysian learners were with Malaysian in week one. However, reaction times overall in week two were faster for everyone, so, although French learners appear to be better with Malaysian in week two, this is due to circumstances, that is they were "lucky" to be presented with French in week one, so appear faster with Malaysian in week two.

Next, reaction times were analysed to see if the accent participants were exposed to in week one would affect reaction times in week two. To do this, the reaction times to the foreign accented sentences in week two were analysed separately (French accented sentences only, then Malaysian accented sentences only), with the accent heard in week one as a fixed factor. For the French accented sentences, there was no significant effect of accent heard in week one, $F1(1,45) < 1$, although mean reaction times were quicker for French learners than for Malaysian learners (French learners – 677.6, Malaysian learners – 689.9). For the Malaysian accented sentences, there was no significant effect of accent heard in week one, $F1(1,45) < 1$, although mean reaction times were quicker for Malaysian learners than for French learners (French learners – 792.4, Malaysian learners – 760.7). The accent heard in week one does not seem to have provided participants with an advantage in week two, with no difference between reaction times to both accents in week two regardless on accent heard in week one.

Discussion of Experiment 1

This first experiment aimed at examining whether; 1) a familiarity effect between different foreign accents could be observed, which would reveal a long-term effect of accent exposure, 2) whether a short term adaptation effect could be induced within a few sentences during the first experimental session, and 3) whether a long-term adaptation effect could also be induced by repeating exposure to a particular accent over a one week interval. The accents under investigation, French and Malaysian, were classified a priori as being respectively familiar and unfamiliar to a general British population from the South-West area. In some respect, the French accent condition acted as a control as compared with the Malaysian one, as any short term or long term benefit from repeated exposure to that accent was not expected.

An effect of accent familiarity in week one was found as reactions times were quicker to the French accented sentences than to the Malaysian accented sentences. In addition, it was found that Malaysian learners' reaction times were slowing down with repeated exposure to Malaysian accented sentences, as compared with the French learners' reaction times which remained stable over time. If this slowing down of reaction times for the Malaysian learners in week one is due to more attention being engaged, it would be expected that they would show fewer errors at the end of the block as compared with the start. However, out of 27 participants, eight displayed more errors at the beginning of the block compared with 10 participants showing more errors at the end of the block (with nine participants displaying the same number of errors). It could be that the time window looked at (corresponding to the presentation of 15 sentences) was too short to allow a beneficial short-term adaptation to the unfamiliar accent.

There does seem to be some form of adaptation to the accent from week one to week two. First, participants did seem to benefit from having been exposed to a particular accent in week 1, as Figure 6 shows a tendency for Malaysian learners to be faster with Malaysian in week two as compared with the French learners. Second, reaction times overall seem to be quicker, suggesting that participants may have improved on the task in general, rather than through adaptation to the accent. However as the sentences used in week two were different from those used in week one it is not possible to compare directly as the sentences in week two may have contained less accent information than those in week one, which would make them easier to process.

An interesting finding was provided by Figure 8, which suggested that participants exposed to a given accent in week one were advantaged in week two when processing the same accent. Although the statistical analysis was not significant, the averages for each accent in week two showed that participants exposed to French in week one performed better with French in week two than those participants exposed to Malaysian in week one, with the same pattern evident for performance with the Malaysian accent in week two.

At this point, many issues remain unresolved. Firstly, until now it was assumed that the difference in reaction times elicited by the French and the Malaysian accents were due to a life-long familiarity effect, however it could also be due to a perceptual distance effect. French and English are both classed as Indo-European languages, which perhaps suggests that they are perceptually close to each other, whereas Malaysian is classed as an Austronesian language, and as such may be perceptually further from English than French is (Bauer, 2007). This point will be investigated in Experiment 4. Second, the so-called familiarity effect found in week one seemed mainly due to one Malaysian speaker out of two, raising the question of the generalisation of these results. It was decided at this point to concentrate on these effects, and therefore Experiments 2 and 3 will investigate familiarity effect and short term exposure effect to accents.

Experiment 2: Short term accent adaptation through exposure to spontaneous speech

The results of Experiment 1 seem to suggest that an unfamiliar foreign accent does impair speech perception, and that simple exposure was not sufficient for adaptation to occur in the short term. On the contrary, a tendency for participant's listening to Malaysian speakers to display slower reaction times at the end of the experimental block in week one was found, rather than an acceleration of word identification, as would be predicted by an adaptation process. This could be because the sentences that the participants were exposed to were not naturally occurring speech, which may have different cues that help the listener adapt to the accent that they are hearing. If this is the case, exposure to naturally occurring accented speech should have the effect of leading to adaptation during the first session. Therefore, in Experiment 2 participants were exposed to naturally occurring speech in the two foreign accents before the experiment took place to see whether adaptation would occur, at least in the presumably unfamiliar Malaysian accent. As this experiment was only looking at short term adaptation effects, participants were only tested in one session, immediately after exposure to naturally occurring speech.

Participants

Sixty-three participants (16 males) with an average age of 20.7 years took part in this study. Of these participants, 31 were in the familiar (French) foreign accent group, and 32 were in the unfamiliar (Malaysian) foreign accent group.

Stimuli

The sentences used in Experiment 1 were used in this study (see appendix A). In addition, two new speakers were recruited, one French accented speaker (aged 36, born and raised in Angers with a standard French accent, in Plymouth for 12 years) and one Malaysian accented speaker (aged 25, in Plymouth for one year), both of whom were female. These speakers were both recorded speaking naturally about a past experience, such as a holiday they had been on, or about the place where they grew up. These recordings lasted for a couple of minutes.

Procedure

The experiment was controlled using a script created using E-prime. Each participant was seated at an individual workstation and wore a set of headphones, which the stimuli were played through. At the beginning of the experiment, the following instructions were displayed on screen: "*listen carefully to the following passage. You* *may be tested on it later".* This instruction was given so participants would concentrate on what they were hearing. The passage of naturally occurring speech, that was relevant to the condition the participant was assigned to, was then played to the participant (i.e. participants in the French accented test block condition were presented with the passage spoken by the French speaker). Following the passage, the participants were then presented with the same lexical decision task that was used during week one of Experiment 1 (participants were presented with a sentence spoken in their own or a foreign accent, and were required to decide whether the last word of the sentence was a real word or a made up non-word), with the accent heard during the foreign accent block the same as the accent of the passage heard at the beginning. Spontaneous speech passages and subsequent test sentences were produced by different speakers.

Results

Out of 2394 expected responses, 337 were excluded (these were for incorrect or no response, responses under 200ms or over 2000ms, and all responses under or over 2.5 times the standard deviation of the mean of each participant). Broken down between conditions, 173 of these errors were in the familiar (French) accent group, and 164 were in the unfamiliar (Malaysian) accent group. In addition, data from six participants were rejected after deletions as there were no responses left in each experimental block to be included. The error scores were analysed to see if there was any differences between the two groups, and between the Plymouth accent and foreign accent blocks, and these can be seen in Table 3.

Table 3: *Mean percentage error scores and standard deviations between experimental blocks, broken down into groups.*

	Plymouth accent block		Foreign accent block	
	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation
French learners	6.24	4.53	24.73	11.04
Malaysian learners	5.12	6.34	32.56	14.52

The error scores were analysed used a repeated measures ANOVA, with one within-participant variable; block (baseline and foreign), and one between-participants variable; group (French learners and Malaysian learners). There was a significant effect of block, $F1(1,55) = 153.77$, $p < .001$, $\eta^2 = .74$, where the percentage of error rates were higher for the foreign accent block compared with the Plymouth accent block. There was no difference between the two groups, $F1(1,55) = 3.37$, $p = .07$, $\eta^2 = .06$, and there was a significant interaction between block and group, $F1(1,55) = 5.83$, $p < .05$, $\eta^2 = .1$. This suggests that the foreign accent sentences were more difficult to comprehend, and so resulted in more errors, than the Plymouth accented sentences, however both groups found the foreign accent block equally difficult to comprehend.

Figure 10 shows the mean reaction times for the two experimental blocks, between the two groups.

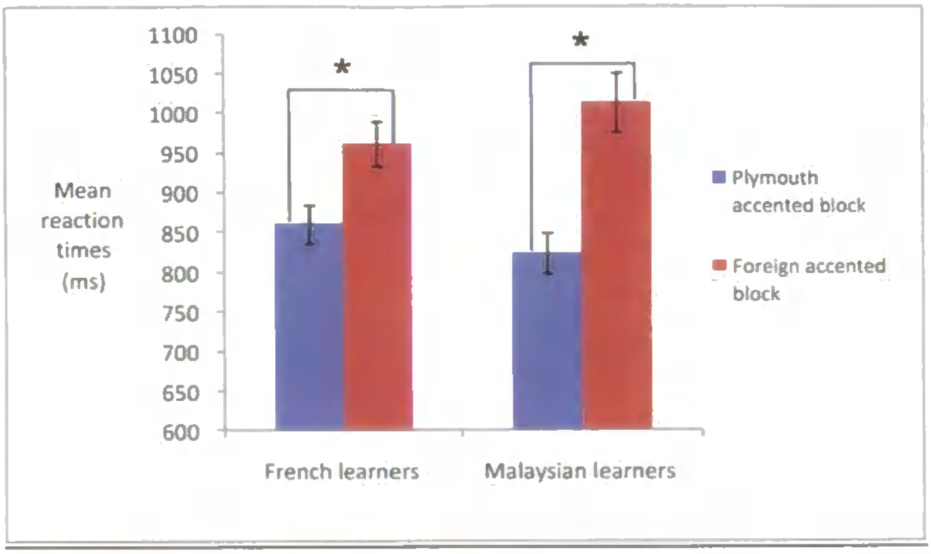

Figure 10: Mean RT's between experiment blocks, broken down into groups.

Reaction times were analysed using a repeated measures ANOVA with two within-participant variables; block (baseline and foreign) and words (word or non-words), and two between-participant variables; group (French learners and Malaysian learners) and speaker (speaker one and speaker two). There was a significant effect of block, $F1(1,53) = 148.08$, $p < .001$, $\eta^2 = .74$, $F2(1,26) = 24.25$, $p < .001$, $\eta^2 = .48$, where reaction times in the baseline block were quicker (Plymouth block average – 838.7, Foreign accent block average – 1016.3). There was a significant effect of words by participant, $F1(1,53) = 6.15$, $p < .05$, $\eta^2 = .1$, but not by item, $F2(1,26) < 1$, where reaction times were quicker to the words than the nonwords (words average – 909.8, nonwords average – 945.2), and there was no significant difference between the groups, $F1(1,53) < 1$, $F2(1,26) < 1$.

There was a significant interaction overall between blocks and group by participant, $F1(1,53) = 21.19$, $p < .001$, $\eta^2 = .29$, but not by item, $F2(1,26) = 2.17$, $p = .15$, $\eta^2 = .08$. There was no difference on the baseline (block one) between the two groups, (French group average – 861, Malaysian group average – 824.3) $F1(1,55) = 1.05$, $p = .31$, $\eta^2 = .02$, $F2(1,28) = 1.65$, $p = .21$, $\eta^2 = .06$, and there was no difference on the foreign accent (block two) between the two groups, $F1(1,55) = 1.27$, $p = .27$, $\eta^2 = .02$, $F2(1,28) < 1$ (French group average – 961.9, Malaysian group average – 1013.6).

Looking at each condition individually, for the French learners there was a significant effect of block, $F1(1,29) = 41.07$, $p < .001$, $\eta^2 = .59$, $F2(1,13) = 10.23$, $p < .01$, $\eta^2 = .44$), and for the Malaysian learners there was also a significant effect of block, $F1(1,24) = 100.36$, $p < .001$, $\eta^2 = .81$, $F2(1,13) = 14.43$, $p < .01$, $\eta^2 = .53$. The size of the effect is much greater for the Malaysian learners than it is for the French learners, which suggests an effect of familiarity, where the French accent is more familiar to the participants and as such leads to a smaller difference between their own accent and French, compared with the difference between their own accent and Malaysian.

Effect of speaker

Speaker effects were again analysed, as shown in Figure 11. As shown in Experiment 1, Malaysian speaker two seems to elicit much slower reaction times. Reaction times to the two French speakers and Malaysian speaker one seem to be much more comparable in these results.

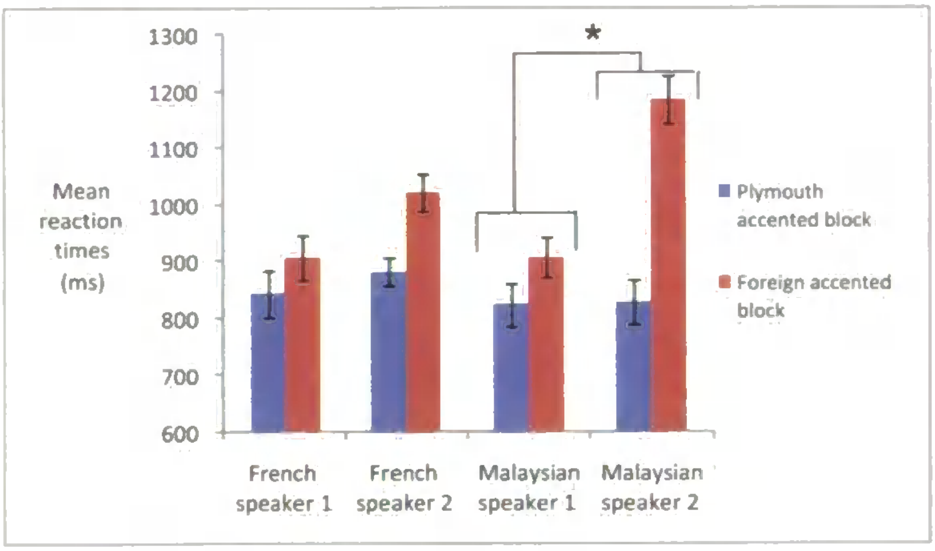

Figure 11: Mean reaction times for each experimental condition, broken down between speakers.

For the French group, there was no effect of speaker heard by participant, $F1(1,29) = 2.61$, $p = .12$, $\eta^2 = .08$, but there was by item, $F2(1,26) = 7.19$, $p < .05$, $\eta^2 = .21$, and there was a significant interaction between block and speaker by participant, $F1(1,29) = 6.5$, $p < .05$, $\eta^2 = .18$, but not by item, $F2(1,26) = 3.48$, $p = .07$, $\eta^2 = .12$. For the Malaysian group, there was a significant effect of speaker heard, $F1(1,24) = 7.81$, $p < .01$, $\eta^2 = .25$, $F2(1,27) = 22.09$, $p < .001$, $\eta^2 = .45$, and there was a significant interaction between block and speaker, $F1(1,24) = 31.93$, $p < .001$, $\eta^2 = .57$, $F2(1,27) = 11.32$, $p < .01$, $\eta^2 = .3$.

In order to see whether any adaptation had occurred with the experimental blocks, the average of the first and last three sentences in each block were calculated and analysed, and are shown in Figure 12.

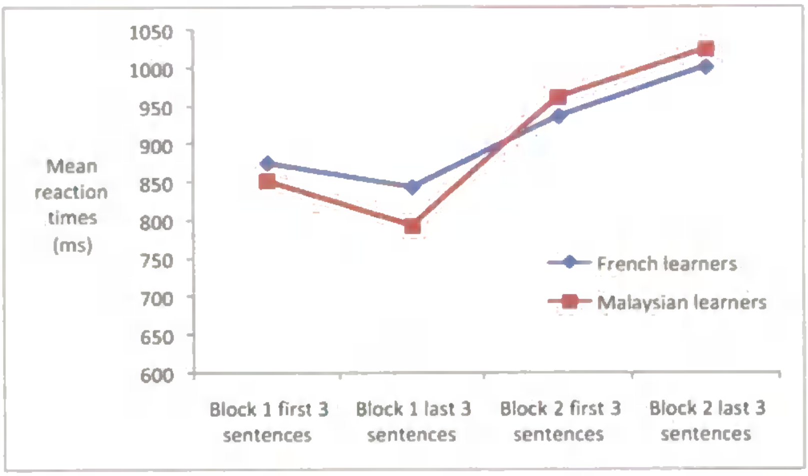

Figure 12: Mean reaction times to the first and last three sentences heard within each experimental block, broken down into groups.

It would seem from the graph that, for both groups, reaction times in the Plymouth block changed very little between the first and last three sentences, and if anything participants' reaction times improved towards the end of the block. There also seems to be a "surprise" effect for both groups when moving from the Plymouth block to the foreign accent block, and reaction times for both groups seem to increase at the end of the block compared with the beginning.

A repeated measures ANOVA was carried out with two within participant variables; block (baseline and foreign accent) and sentences (first three and last three), and two between participant variables; group (French learners or Malaysian learners) and speaker (speaker one or speaker two). There was a significant interaction between block and sentences, $F1(1,50) = 6.255$, $p < .05$, $\eta^2 = .111$, and there was no interaction between block, sentences and group, $F1(1,50) < 1$.

Looking at the two groups separately, for the French learners there was no significant effect of sentences in the baseline block, $F1(1,28) = 1.4$, $p = .25$, $\eta^2 = .05$ (first three sentences average – 876.1, last three sentences average – 844.2), and no difference between the first and last three sentences heard in the foreign accent block, $F1(1,28) = 1.45$, $p = .24$, $\eta^2 =.05$ (first three sentences average – 937.5, last three sentences average – 1001.8). For the Malaysian learners, there was a significant difference between the first and last three sentences heard in the baseline block, $F1(1,23) = 5.32$, $p < .05$, $\eta^2 = .19$ (where reaction times were quicker to the last three sentences in the block compared with the first three, first three sentences average – 852.2, last three sentences average – 793.1), and there was no significant difference between the first and last three sentences heard in the foreign accent block, $F1(1,23) = 1.07$, $p = .31$, $\eta^2 = .05$ (first three sentences average – 962.3, last three sentences average – 1025).

Comparison between Experiment 1 and 2

Experiments 1 and 2 were compared to see whether there were any differences between participants who had been exposed to natural speech (Experiment 2) or not (Experiment 1), and the reaction times are shown in Figure 13. This seems to show that reaction times are generally slower in Experiment 2 compared with Experiment 1, particularly in the French learners condition, where participants in Experiment 2 seem to be a lot slower compared with Experiment 1.

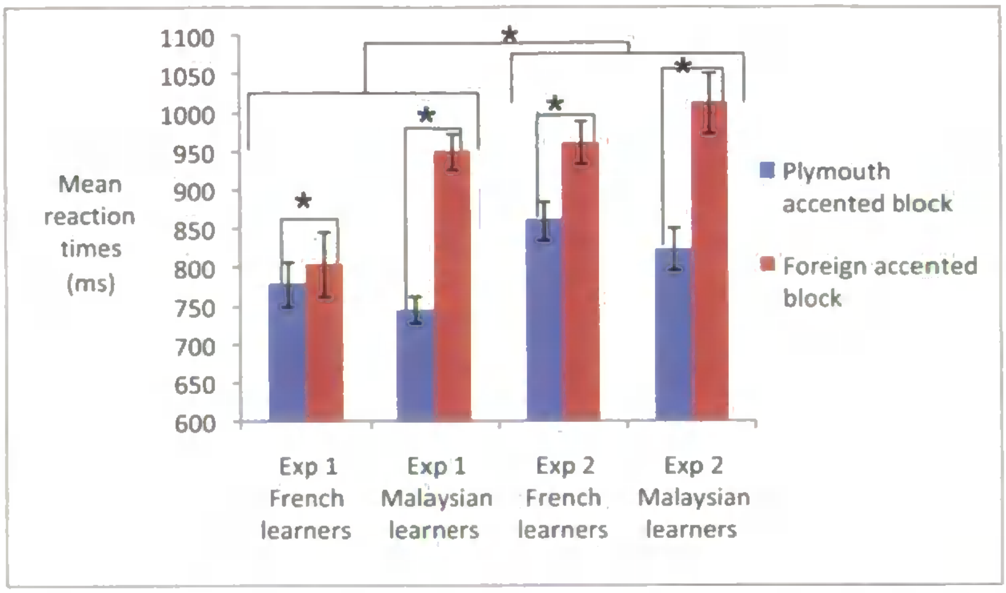

Figure 13: Mean RTs between experimental blocks between Experiments 1 and 2, broken down into groups.

Reaction times were analysed through an ANOVA with one within-participant variable; block (baseline and foreign), and two between-participant variables; group (French learners and Malaysian learners) and experiment (1 or 2). There was a significant main effect of block, $F1(1,108) = 112.25$, $p < .001$, $\eta^2 = .51$, $F2(1,56) = 50.69$, $p < .001$, $\eta^2 = .48$ where across both experiments, reaction times in block one, baseline, were quicker than in block two, foreign accent block (block one average – 802.62, block two average – 933.04). There was no main effect of group, $F1(1,108) = 1.46$, $p = .23$, $\eta^2 = .01$, $F2(1,56) = 2.55$, $p = .12$, $\eta^2 = .04$, and a significant main effect of experiment, $F1(1,108) = 12.81$, $p < .001$, $\eta^2 = .12$, $F2(1,56) = 35.91$, $p < .001$, $\eta^2 = .39$, where reaction times were quicker in Experiment 1 than in Experiment 2 (Experiment 1 average – 820.5, Experiment 2 average – 915.2). There was no interaction between block, group and experiment, although it was marginal by participant, $F1(1,108) = 3.42$, $p = .07$, $\eta^2 = .03$, $F2(1,56) = 1.98$, $p = .17$, $\eta^2 = .03$, and there was no interaction between group and experiment, $F1(1,108) = 1.41$, $p = .24$, $\eta^2 = .01$, $F2(1,56) < 1$. There was a significant difference on the baseline (block one) between experiments, $F1(1,108) = 10.6$, $p < .01$, $\eta^2 = .09$, $F2(1,56) = 17.34$, $p < .001$, $\eta^2 = .24$, where reaction times were quicker in Experiment 1 compared with Experiment 2 (Experiment 1 average – 762.6, Experiment 2 average – 842.6), and no interaction between group and experiment, $F1(1,108) < 1$, $F2(1,56) < 1$. There was a significant difference on the foreign accent (block two) between experiments, $F1(1,108) = 10.88$, $p < .01$, $\eta^2 = .09$, $F2(1,56) = 14.75$, $p < .001$, $\eta^2 = .21$, where reaction times were quicker in Experiment 1 compared with Experiment 2 (Experiment 1 average – 878.4, Experiment 2 average – 987.7), and no interaction between group and experiment, $F1(1,108) = 2.03$, $p = .16$, $\eta^2 = .02$, $F2(1,56) = 3.82$, $p = .07$, $\eta^2 = .06$.

The first and last three sentences of each block were also compared across Experiments 1 and 2, as shown in Figure 14. The Malaysian learners in Experiment 1 and both groups in Experiment 2 seem to show reaction times getting slower at the end of block two compared with the beginning, with French learners in Experiment 1 showing fairly stable reaction times. There appears to be improvement for all participants during block one.

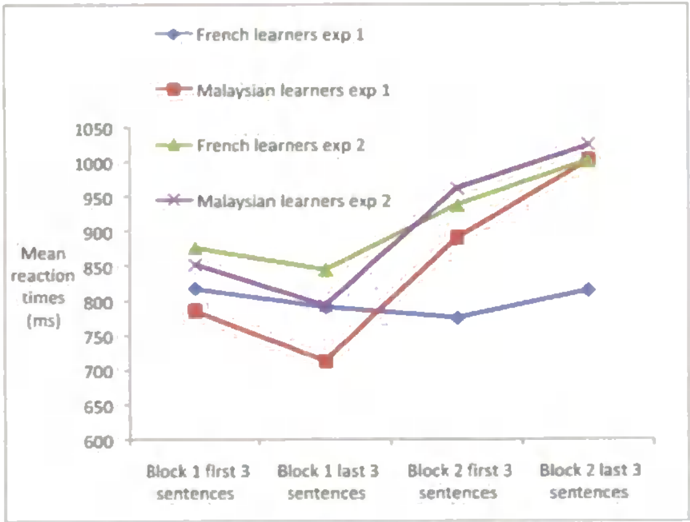

Figure 14: Mean reaction times to the first and last three sentences heard within each experimental block, broken down into groups and experiments.

A repeated measures ANOVA with two within participant variable; block (baseline block one and foreign accent block two) and sentences (first three sentences and last three sentences), and three between participant bariables; group (French learners and Malaysian learners), speaker (speaker one and speaker two) and experiment

(Experiment 1 and Experiment 2), showed no interaction between block, sentences, group and experiment, $F1(1,99) < 1$.

Discussion of Experiment 2

Experiment 2 explored the possibility that the lack of short-term adaptation to an unfamiliar accent as evidenced in Experiment 1 would be due to participants' lack of exposure to natural accented speech. Therefore participants were exposed to a couple of minutes of spontaneous accented speech prior to the lexical decision task. Results showed that the unfamiliar Malaysian accent elicited slower RT than the more familiar French accent, and although the effect appeared somewhat weaker than in Experiment 1, it was statistically not different. Taken together with the results of Experiment 1, Experiment 2 suggests that the familiarity effect – or the perceptual distance effect - is rather robust, whereas signs of short-term adaptation are absent at this point.

Experiment 3: Effect of instructions on short term adaptation

Some previous studies suggest that adaptation to an accent is possible through exposure to natural accented speech (Bradlow and Bent, 2008; Clarke and Garrett, 2004; Dahan et al., 2008; Maye et al., 2008), standing in sharp contrast with results of Experiment 2 which did not show any evidence of adaptation. Rather, it was found that on the overall, reaction times were slower in Experiment 2 than in Experiment 1. This could be due to a sampling effect, but it is also possible that the instructions to concentrate on the passage given at the beginning of Experiment 2 may have had the effect that the participants were focusing too much on what they heard in the passage in case they were tested on it, which may have affected performance on the lexical decision task. Similarly to Experiment 2, Adank and McQueen (2007) presented participants with accented speech to try and induce adaptation, however, as a distracter task, the participants were required to decide whether the subject of each sentence in the passage was singular or plural. They found no evidence of adaptation to the accent, which could have been due to the participants focusing more on the distracter task rather than processing the accent. In order to examine whether this was the case with participants in Experiment 2, Experiment 3 was designed so that the participants' attention was not directed elsewhere. This was done by changing the instructions before the presentation of the passage, to "*please relax and listen to the following passage*" instead of "*please listen carefully to the following passage, you may be tested on it later*".

Participants

Fifty-eight participants (17 males) with an average age of 22.6 took part in this study. Of these participants, 29 were in the familiar (French) foreign accent group, and 29 were in the unfamiliar (Malaysian) foreign accent group.

Stimuli

The stimuli used were the same as the stimuli used in Experiment 2.

Procedure

The procedure used was the same as for Experiment 2, except the instructions given before the passage of naturally produced speech were changed to "*please relax and listen to the following passage*".

Results

Out of 2280 expected responses, 343 were excluded. These were for incorrect or no response, responses under 200ms or over 2000ms, and all responses under or over 2.5 times the standard deviation of the mean. Broken down between conditions, 153 incorrect responses were in the familiar (French) accent group, and 190 were in the unfamiliar (Malaysian) accent group. In addition, data for two participants were rejected after deletions as there was not enough data left in each experimental condition. The error scores were analysed to see if there was any differences between the two groups, and between the Plymouth accent and foreign accent blocks, and these can be seen in Table 4.

Table 4: *Mean percentage error scores and standard deviations between experimental blocks, broken down into groups.*

	Plymouth accent block		Foreign accent block	
	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation
French learners	4.83	5.61	22.99	10.78
Malaysian learners	3.91	4.55	31.95	15.05

The error scores were analysed used a repeated measures ANOVA, with one within-participant variable; block (baseline and foreign), and one between-participants variable; group (French learners and Malaysian learners). There was a significant effect of block, $F1(1,56) = 146.34$, $p < .001$, $\eta^2 = .72$, where the percentage of error rates were higher for the foreign accent block compared with the Plymouth accent block. There was a significant effect of group, $F1(1,56) = 5.12$, $p < .05$, $\eta^2 = .08$, where error rates in the foreign accent block were higher for the Malaysian learners compared with the French learners, and there was a significant interaction between block and group, $F1(1,56) = 6.7$, $p < .05$, $\eta^2 = .11$. This suggests that the foreign accent sentences were more difficult to comprehend, and so resulted in more errors, than the Plymouth accented sentences, and also that the Malaysian accented sentences were more difficult to comprehend than the French accented sentences.

Figure 15 shows the mean reaction times for the two experimental blocks, between the two groups.

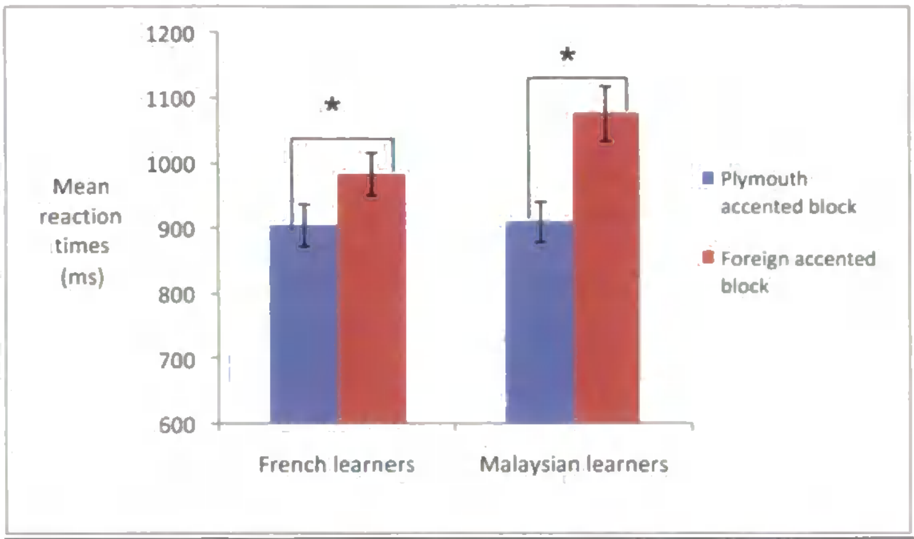

Figure 15: Mean RT's between experimental blocks, broken down into groups.

Reaction times were analysed using a repeated measures ANOVA with two within-participant variables; block (baseline and foreign) and words (word or non-words), and two between-participant variables; group (French learners and Malaysian learners) and speaker (speaker one and speaker two). There was a significant effect of block, $F1(1,54) = 59.22$, $p < .001$, $\eta^2 = .52$, $F2(1,26) = 12.2$, $p < .01$, $\eta^2 = .32$, where reaction times in the baseline block were quicker (baseline block average – 906.6, foreign accent block average – 1035.0). There was no effect of words, $F1(1,54) = 1.88$, $p = .18$, $\eta^2 = .03$, $F2(1,26) < 1$, and there was no difference between the groups, $F1(1,54) = 1.77$, $p = .19$, $\eta^2 = .03$, $F2(1,26) < 1$.

As can be inferred from Figure 15, there was a significant overall interaction between block and groups by participant, $F1(1,54) = 7.9$, $p < .01$, $\eta^2 = .13$, but not by item, $F2(1,26) < 1$. There was no difference on the baseline (block one) between the two groups, $F1(1,56) < 1$, $F2(1,28) < 1$, and no difference on the foreign accent (block two) between the two groups, $F1(1,56) = 3.08$, $p = .09$, $\eta^2 = .05$, $F2(1,28) < 1$.
Looking at the groups individually, for the French learners there was a significant effect of block by participant, $F1(1,27) = 14.94$, $p < .01$, $\eta^2 = .36$, but not by item, $F2(1,13) = 3.12$, $p = .1$, $\eta^2 = .19$, and for the Malaysian learners there was a significant effect of block, $F1(1,27) = 45.94$, $p < .001$, $\eta^2 = .63$, $F2(1,13) = 12.99$, $p < .01$, $\eta^2 = .5$. The size

of the effect is much greater for the Malaysian learners than it is for the French learners, which suggests that there is some trace of adaptation to the French accent.

Effect of speaker

Speaker effects were again analysed, as shown in Figure 16. Similarly to Experiment 2, reaction times to Malaysian speaker two seem to be much slower compared with Malaysian speaker one, and reaction times to the two French speakers and Malaysian speaker one seem comparable.

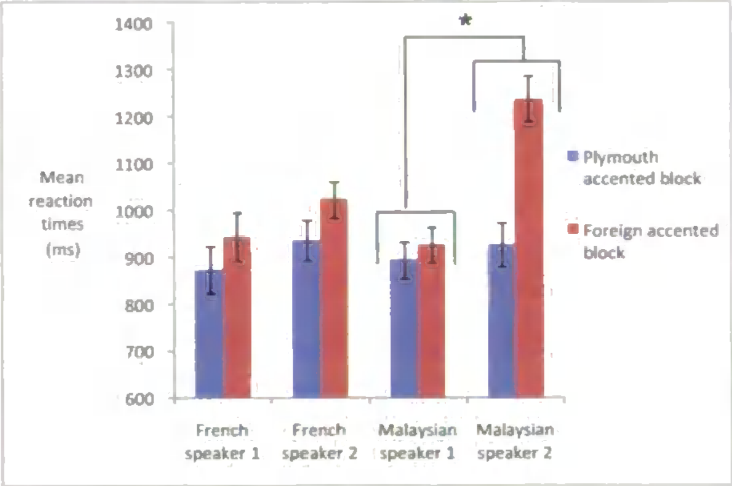

Figure 16: Mean reaction times for each experimental condition, broken down between speakers.

For the French group, there was no effect of speaker heard, $F1(1,27) = 1.3$, $p = .26$, $\eta^2 = .05$, $F2(1,28) = 1.26$, $p = .27$, $\eta^2 = .04$, and there was no interaction between block and speaker, $F1(1,27) < 1$, $F2(1,28) < 1$. For the Malaysian group, there was a significant effect of speaker heard, $F1(1,27) = 9.78$, $p < .01$, $\eta^2 = .27$, $F2(1,27) = 38.45$, $p < .001$, $\eta^2 = .59$, and there was a significant interaction between block and speaker, $F1(1,27) = 27.85$, $p < .001$, $\eta^2 = .51$, $F2(1,27) = 17.9$, $p < .01$, $\eta^2 = .4$.

In order to see whether any adaptation had occurred with the experimental blocks, the average of the first and last three sentences in each block were calculated and analysed, and are shown in Figure 17.

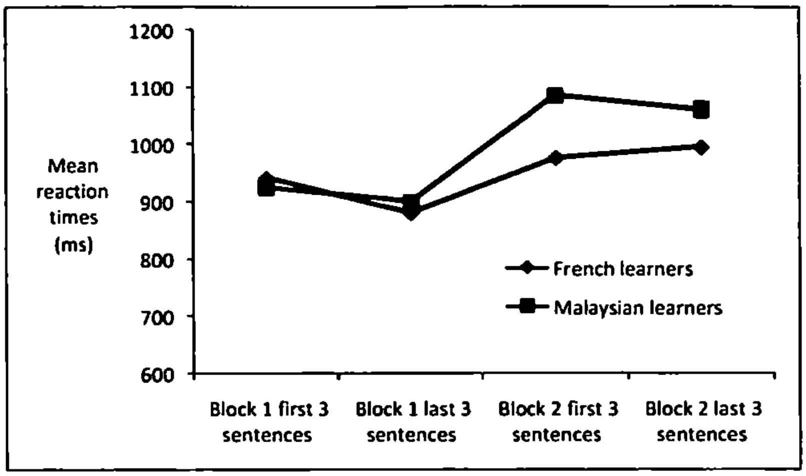

Figure 17: Mean reaction times to the first and last three sentences heard in each experimental condition, broken down into groups.

A repeated measures ANOVA was carried out with two within participant variables; block (baseline and foreign accent) and sentences (first three and last three), and two between participant variables; group (French learners or Malaysian learners) and speaker (speaker one or speaker two). There was no interaction between block sentence and group, $F1(1,50) = 1.41$, $p = .24$, $\eta^2 = .03$.

Looking at the two groups individually, for the French learners there was no significant effect of sentences in the baseline block, $F1(1,28) = 2.28$, $p = .14$, $\eta^2 = .08$ (first three sentences average – 941.2, last three sentences average – 880.7), and there was no significant effect of sentences in the foreign accent block, $F1(1, 28) < 1$ (first three sentences average – 976.5, last three sentences average – 995.3). For the Malaysian learners, there was no significant effect of sentences in the baseline block, $F1(1,24) < 1$ (first three sentences average – 925.8, last three sentences average – 901.5), and no significant effect of sentences in the foreign accent block, $F1(1,24) < 1$ (first three sentences average – 1069.3, last three sentences average – 1037.7).

Comparison between Experiments 1 and 3

Experiments 1 and 3 were compared with see whether there were any differences between participants who had been exposed to natural speech (Experiment 3) or not (Experiment 1), and the reaction times are shown in Figure 18. This seems to show that reaction times are generally slower in Experiment 3 compared with Experiment 1, particularly in the French learners condition, where participants in Experiment 3 seem to be a lot slower compared with Experiment 1.

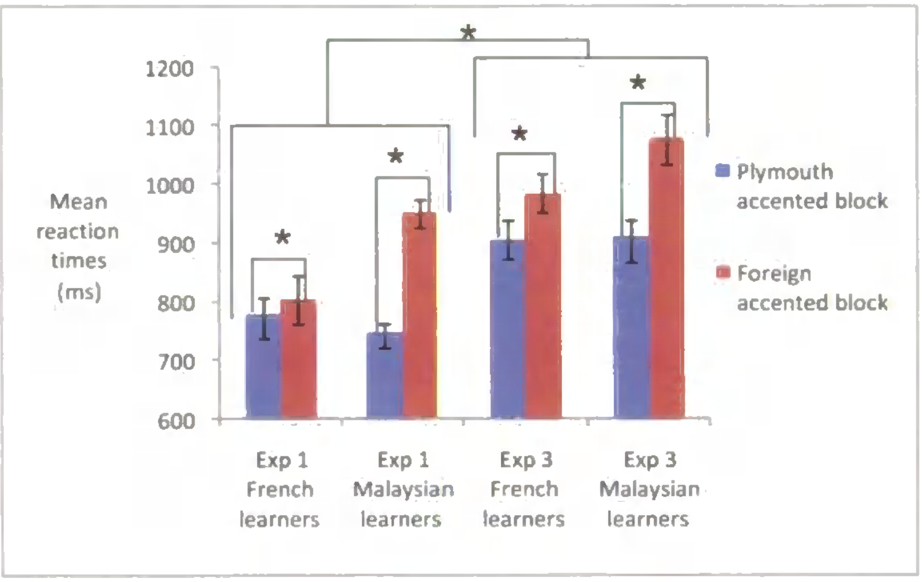

Figure 18: Mean RTs between experimental blocks between Experiments 1 and 3, broken down into groups.

Reaction times were analysed using a repeated measures ANOVA with one within-participant variable; block (baseline and foreign), and two between-participant variables; group (French learners and Malaysian learners) and experiment (1 or 3). There was a significant main effect of block, $F1(1,109) = 79.69$, $p < .001$, $\eta^2 = .42$, $F2(1,56) = 34.81$, $p < .001$, $\eta^2 = .38$, where reaction times in the baseline block were quicker (baseline block average – 835, foreign accent block average – 954.5). There was no main effect of group, $F1(1,109) = 3.21$, $p = .08$, $\eta^2 = .03$, $F2(1,56) = 2.84$, $p = .1$, $\eta^2 = .05$, but there was a significant main effect of experiment, $F1(1,109) = 25.87$, $p < .001$, $\eta^2 = .19$, $F2(1,56) = 73.32$, $p < .001$, $\eta^2 = .57$, where reaction times in Experiment 1 were quicker compared with Experiment 3 (Experiment 1 average – 820.5, Experiment 3 average – 969). There was no interaction between block, group and experiment by participant, $F1(1,109) = 2.93$, $p = .09$, $\eta^2 = .03$, but there was by item, $F2(1,56) = 4.15$, $p < .05$, $\eta^2 = .07$, and there was no interaction between group and experiment, $F1(1,109) < 1$, $F2(1,56) < 1$. There was a significant difference on the baseline (block one) between experiments, $F1(1,109) = 26.41$, $p < .001$, $\eta^2 = .2$, $F2(1,56) = 56.62$, $p < .001$, $\eta^2 = .5$, and there was no interaction between group and experiment, $F1(1,109) < 1$, $F2(1,56) < 1$. There was a significant difference on the foreign accent (block two) between experiments, $F1(1,109) = 18.25$, $p < .001$, $\eta^2 = .14$, $F2(1,56) = 22.64$, $p < .001$, $\eta^2 = .29$, and there was no interaction between group and experiment, although it was marginal by item, $F1(1,79) < 1$, $F2(1,56) = 3.77$, $p = .06$, $\eta^2 = .06$.

This comparison shows that reaction times are still faster overall in Experiment 1. Also, just as in Experiment 2, it shows a tendency for the accent familiarity effect to be somewhat weaker than in Experiment 1.

The first and last three sentences of each block were also compared across Experiments 1 and 3, as shown in Figure 19. Within block two, reaction times seem to remain relatively stable across the group except for the Malaysian learners in Experiment 1, which suggests that they needed to engage more attention than the Malaysian learners in Experiment 3. There appears to be improvement for all participants during block one.

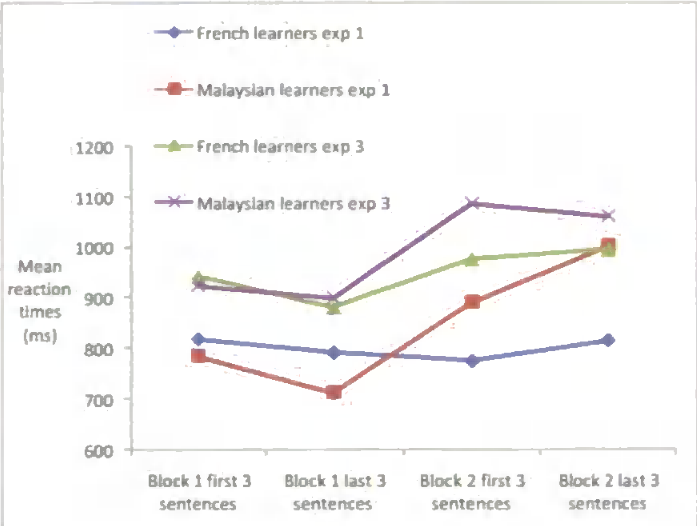

Figure 19: Mean reaction times to the first and last three sentences heard within each experimental block, broken down into groups and experiments.

A repeated measures ANOVA with two within participant variables; block (baseline block one and foreign accent block two) and sentences (first three sentences and last three sentences), and three between participant variables; group (French learners and Malaysian learners), speaker (speaker one and speaker two) and Experiment (Experiment 1 and Experiment 2), showed no interaction between block, sentences, group and experiment, although it was extremely borderline, $F1(1,99) = 3.83$, $p = .053$, $\eta^2 = .04$.

Comparison between Experiments 2 and 3

Experiments 2 and 3 were compared with see whether there were any differences between participants where the instructions were different before exposure to natural speech (Experiment 2, pay attention; Experiment 3 relax), and the reaction times are shown in Figure 20. This seems to show that reaction times are fairly similar between participants in both experiments.

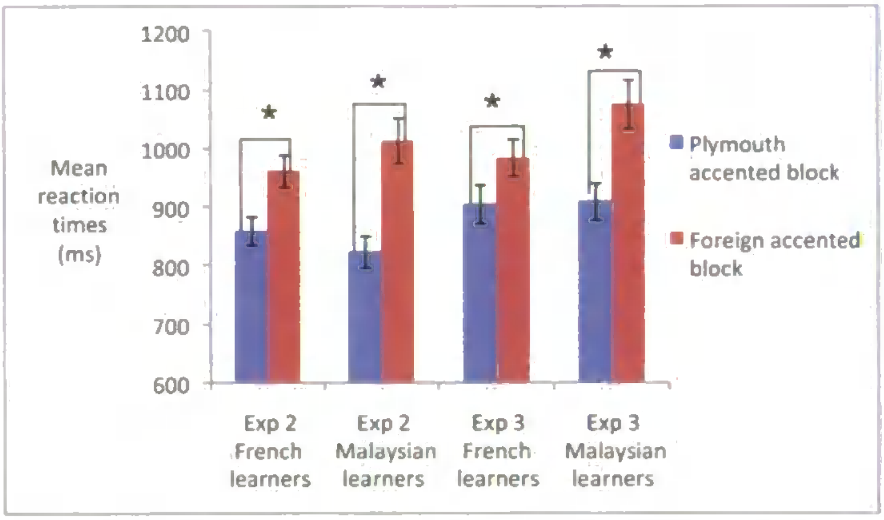

Figure 20: Mean RTs between experimental blocks between Experiments 1 and 3, broken down into groups.

Reaction times were analysed using an ANOVA with one within-participant variable; block (baseline and foreign), and two between-participant variables; group (French learners and Malaysian learners) and experiment (2 and 3). There was a significant main effect of block, $F1(1,111) = 91.23$, $p < .001$, $\eta^2 = .45$, $F2(1,56) = 30.6$, $p < .001$, η^2

= .35, where reaction times in the baseline block were quicker (baseline block average – 875.1, foreign accent block average – 1009.1). There was no main effect of group, $F1(1,111) < 1$, $F2(1,56) < 1$, and there was no main effect of experiment by participant, $F1(1,111) = 3.51$, $p = .06$, $\eta^2 = .03$, but there was by item, $F2(1,56) = 10.42$, $p < .01$, $\eta^2 = .16$ (Experiment 2 average – 915.2, Experiment 3 average – 969). There was no interaction between block, group and experiment, $F1(1,111) < 1$, $F2(1,56) < 1$, and there was no interaction between group and experiment, $F1(1,111) < 1$, $F2(1,56) < 1$. There was a significant difference on the baseline (block one) between experiments, $F1(1,111) = 5.1$, $p < .05$, $\eta^2 = .04$, $F2(1,56) = 8.6$, $p < .01$, $\eta^2 = .13$, where reaction times in Experiment 2 were quicker on the baseline compared with Experiment 3 (Experiment 2 average – 842.6, Experiment 3 average – 907.5) and there was no interaction between group and experiment, $F1(1,111) < 1$, $F2(1,56) < 1$. There was no difference on the foreign accent (block two) between experiments, $F1(1,111) = 1.5$, $p = .22$, $\eta^2 = .22$, $F2(1,56) = 2.19$, $p = .14$, $\eta^2 = .04$, and there was no interaction between group and experiment, $F1(1,111) < 1$, $F2(1,56) < 1$. This comparison shows that the familiarity effect is clearly the same in both experiments.

The first and last three sentences of each block were also compared across Experiments 2 and 3, as shown in Figure 21. Within block two, there appears to be differences between participants in the two experiments, where reaction times seem to be getting slower for both French and Malaysian learners in Experiment 2, while reaction times seem to remain relatively stable in for both groups in Experiment 3. There appears to be improvement for all participants during block one.

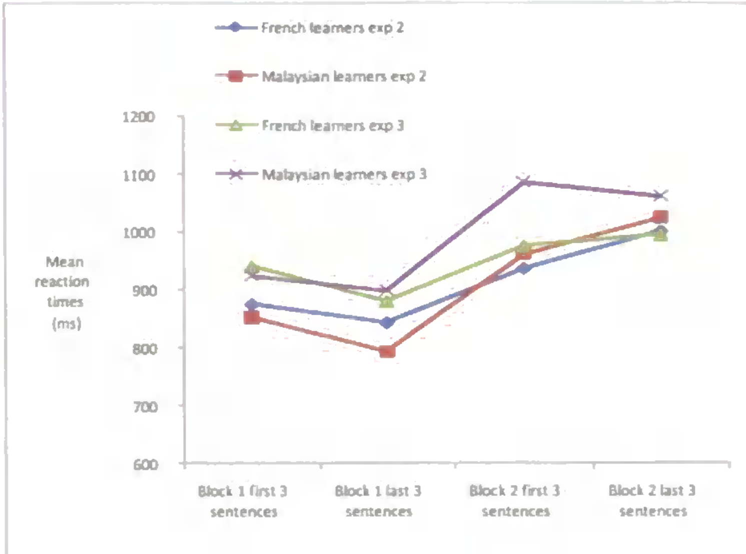

Figure 21: Mean reaction times to the first and last three sentences heard within each experimental block, broken down into groups and experiments.

A repeated measures ANOVA with two within participant variables; block (baseline block one and foreign accent block two) and sentences (first three sentences and last three sentences), and three between participant variables; group (French learners and Malaysian learners), speaker (speaker one and speaker two) and experiment (Experiment 2 and Experiment 3), showed no interaction between block, sentences, group and experiment, $F1(1,100) = 1.11$, $p = .3$, $\eta^2 = .01$.

Discussion of Experiment 3

This experiment was designed to investigate whether a change in the instructions prior to the presentation of the spontaneous accented speech would help accelerating reaction times in the subsequent lexical decision task, and maybe uncover adaptation effects. Results showed that even though reaction times were at a similar level as in Experiment 2, the accent familiarity effect was still found, and it was somewhat weaker than in Experiment 1. However this was only partially confirmed by the statistical analyses as the effect in Experiment 1 is different from that in Experiment 3 by item only. The effect found in Experiment 3 is nevertheless very comparable to what was found in Experiment 2.

At this point two issues need to be addressed; 1) the origins of the recurrent familiarity effect, and 2) the short term benefit of accent exposure. Regarding the first point, it was found in the three experiments that the French accent elicited faster reaction times than the Malaysian accent. This could be due to an affect of familiarity, where participants have been exposed over a long term period to the French accent through their lives, and so have already learnt something about this accent, whereas participants may not have been exposed to a Malaysian accent in the same way. It could also be due to an effect of perceptual distance between these two speech styles, independently of familiarity (or superimposed on).

Methodologically the problematic point is that the effect was mainly due to one Malaysian speaker over the other, who elicited reaction times very comparable to those of the two French speakers. Experiment 4 will introduce two new accents (and therefore four new speakers) to investigate whether the so-called accent familiarity effect can be generalised.

Experiment 4: Generalisation of effect of accent familiarity

So far a possible accent familiarity effect has been demonstrated, with reaction times slower to the unfamiliar Malaysian accent compared with the familiar French accent in Experiment 1. This finding remained relatively stable over Experiments 2 and 3, where exposure to naturally occurring speech before the test phase did not seem to facilitate any short term adaptation to either the familiar or unfamiliar accent. The next experiment will concentrate on the origins of this familiarity effect. This experiment wanted to ascertain whether the processing costs demonstrated so far can be generalised across other accents or whether the results are restricted to the accents we have tested so far (French and Malaysian), or even to particular speakers. Two new accents were introduced, German and Hungarian, and it was theorised that German would be an accent that could be seen to be familiar to the participants whereas the Hungarian accent would be less well known to them, and so could be classified as an unfamiliar accent. However, Hungarian is classed as an Ugric language, as opposed to Malaysian, which belongs to the Austronesian family of languages (Bauer, 2007), therefore it was assumed that Hungarian would be an unfamiliar accent to the participants that would also be perceptually further from English (because it is not an Indo-European language) in the same way that Malaysian could be.

Participants

Eighty-seven participants (20 males) with an average age of 19.3 years took part in this study. Of these participants, 43 were in the familiar (German) foreign accent condition, and 44 were in the unfamiliar (Hungarian) foreign accent group.

Stimuli

The stimuli used in this experiment were identical to those used in Experiment 1 (see appendix A), however the two French accented speakers were replaced by two German accented speakers (speaker one - aged 34, in Plymouth for two years; speaker two – aged 40, in Plymouth for three years) and the two Malaysian accented speakers were replaced with two Hungarian accented speakers (speaker one – aged 34, in Plymouth for eight years; speaker two – aged 31, in Plymouth for three years). For control purposes all speakers were female. The results of the average rating experiment showed that the average rating for the German accented sentences was 2.55, and for the Hungarian speakers was 2.75. Including the accent ratings for the two Plymouth speakers, overall there was no effect of accent, $F1(2,18) < 1$. There was no effect of accent between Plymouth and German, $F1(1,9) < 1$, no effect of accent between Plymouth and Hungarian, $F1(1,9) < 1$, and no effect of accent between German and Hungarian, $F1(1,9) = 1.35$, $p = .28$, $\eta^2 = .13$. For the German speakers, the average rating in the accent rating experiment for speaker G1 (3.12) was significantly higher than for speaker G2 (1.98), $t = 6.37$, $df = 9$, $p < .001$. The 95% confidence interval was .74 to 1.54, and the effect size was 2.37. For the Hungarian speakers, the average rating for speaker H1 (2.08) was significantly lower than for speaker H2 (3.72), $t = 5.8$, $df = 9$, $p < .001$. The 95% confidence interval was -1.86 to -.82, and the effect size was 2.55. Although the rating differences between the speakers of German and Hungarian seem to be smaller than the differences observed between the two Malaysian speakers in Experiment 1 (see pages 35 to 36), the rating results clearly show that there are differences between all pairs of speakers, and that one of the speakers is always rated as having a much stronger accent than the other. However, it is difficult to judge whether the speakers rated as the highest level of accent is due to the average level of accent in these experiments. In other words, if a speaker with a heavier accent was added to the accent rating experiment, the chances are that the current speakers would be rated as having a lower accent compared with the ratings reported here.

Procedure

The procedure used was identical to that used in week one of Experiment 1 (there was no session two in week two), except for the speakers heard in the foreign accent block were different.

Results

Out of 3306 expected responses, 480 were excluded. These were for incorrect or no responses, responses under 200ms or over 2000ms, and all responses under or over 2.5 times the standard deviation of the mean of each participant. Broken down between conditions, 196 incorrect responses were in the familiar (German) accent group, and 284 were in the unfamiliar (Hungarian) accent group. In addition, two participants were excluded from the study because after deletions they both only had one response to the non-word sentences in the foreign accent block. The error scores were analysed to see if there was any differences between the two groups, and between the Plymouth accent and foreign accent blocks, and these can be seen in Table 5.

Table 5: *Mean percentage error scores and standard deviations between experimental blocks, broken down into groups.*

	Plymouth accent block		Foreign accent block	
	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation
German learners	4.6	6.33	19.21	10.64
Hungarian learners	9.3	8.62	28.68	12.73

The error scores were analysed used a repeated measures ANOVA, with one within-participant variable; block (baseline and foreign), and one between-participants variable; group (German learners and Hungarian learners). There was a significant effect of block, $F1(83) = 180.33$, $p < .001$, $\eta^2 = .66$, where the percentage of error rates were higher for the foreign accent block compared with the Plymouth accent block. There was a significant effect of group, $F1(1,83) = 16.77$, $p < .001$, $\eta^2 = .17$, where error rates were higher for the Hungarian learners compared with the German learners, and there was no interaction between block and group, $F1(1,83) = 3.56$, $p = .06$, $\eta^2 = .04$. This suggests that the foreign accent sentences were more difficult to comprehend, and so resulted in more errors, than the Plymouth accented sentences, and also the difference between the two groups, and the lack of interaction, suggests that Hungarian learners found both Plymouth and Hungarian accented sentences more difficult to comprehend than the German learning participants (although the interaction was borderline significant, and the difference between the groups on the foreign accent blocks is greater than the difference on the Plymouth accented block).

Figure 22 shows the mean reaction times for the two experimental blocks between the two groups.

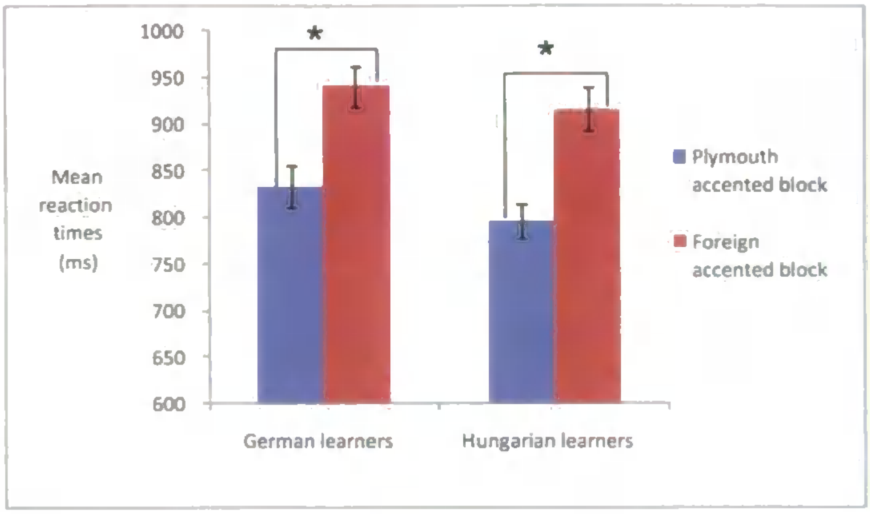

Figure 22: Mean reaction times (RT) between experimental blocks, broken down into groups.

Reaction times were recorded for each response, and were analysed using a repeated measures ANOVA with two within-participant variables; block (baseline and foreign) and words (word or non-word), and two between-participant variables; group (German learners and Hungarian learners) and speaker (speaker one and speaker two). There was a significant main effect of block, $F1(1,81) = 107.88$, $p < .001$, $\eta^2 = .57$, $F2(1,28) = 20.49$, $p < 001$, $\eta^2 = .42$, where reaction times in block two are quicker than reaction times in block one (block one average – 812.6, block two average – 931.3). There was no main effect of group, $F1(1,81) = 1.53$, $p = .22$, $\eta^2 = .02$, $F2(1,28) < 1$. There was no effect of words, $F1(1,81) <1$, although reaction times were slightly quicker to words than to nonwords (words average – 868.3, nonwords average – 875.7).

There was no interaction between blocks and group, $F1(1,81) < 1$, $F2(1,28) < 1$. There was no significant difference on the baseline (block 1) between the groups, $F1(1,83) = 1.5$, $p = .22$, $\eta^2 = .02$, $F2(1,28) < 1$, and no significant difference on the foreign accent block between the groups, $F1(1,83) = 1.14$, $p = .29$, $\eta^2 = .01$, $F2(1,28) < 1$.

Effect of Speaker

Speaker effects were investigated, as shown in Figure 23. There does not seem to be a great difference in performance for each speaker, although perhaps reaction times were quicker for Hungarian speaker one than Hungarian speaker two.

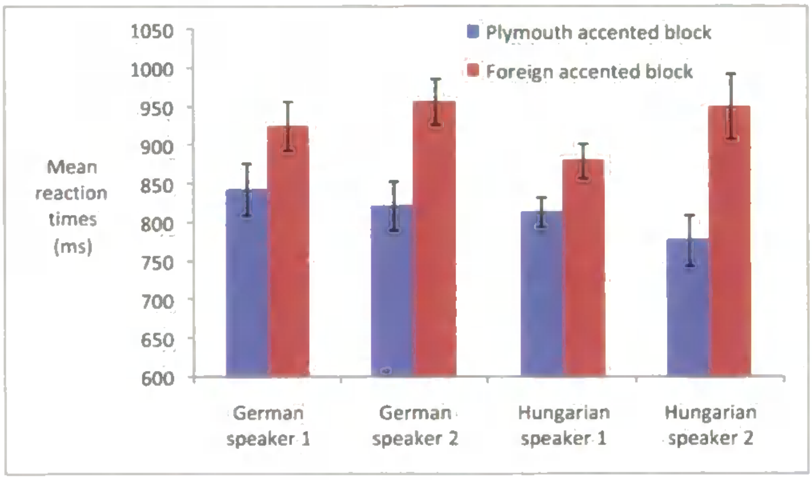

Figure 23: Mean reaction times for each experimental condition, broken down between speakers.

In the German accent group, there was no effect of speaker, $F(1,40) < 1$, but there was a significant interaction between block and speaker, $F(1,40) = 4.29$, $p < .05$, $\eta^2 = .1$. In the Hungarian accent group, there was no effect of speaker, $F(1,41) < 1$, but there was a significant interaction between block and speaker, $F(1,41) = 7.33$, $p < .01$, $\eta^2 = .15$.

In order to see whether participants had learnt about the foreign accent during the block, averages were computed for the first and last three sentences heard within both blocks. Figure 24 seems to show that participants in both groups show an improvement towards the end of the baseline block over the beginning, and then both groups show a large increase in reaction times at the beginning of the foreign accent block (compared with the baseline block). There does not seem to be any improvement over the course of the foreign accent block for either group, and in fact it would appear that the Hungarian accent group's reaction times got worse over the course of the block, similarly to that found in Experiment 1 (French and Malaysian accents).

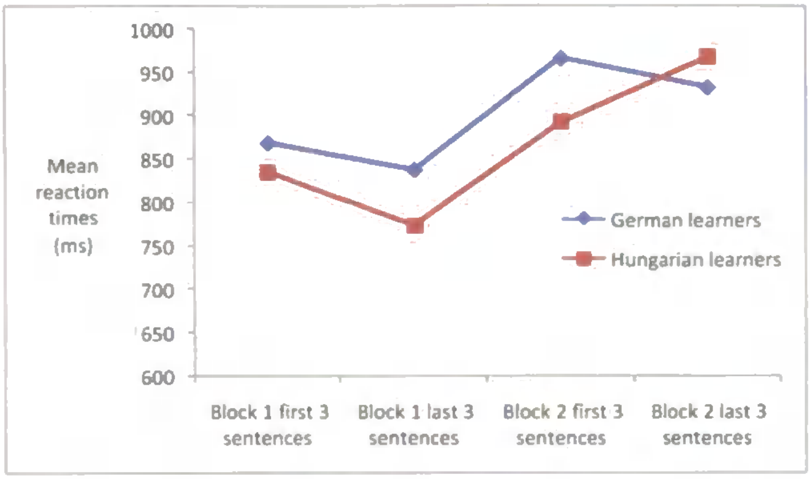

Figure 24: Mean reaction times to the first and last three sentences heard within each experimental block, broken down into groups.

A repeated measures ANOVA with two within participants variables; block (baseline and foreign accent) and sentences (first three and last three), and two between participants variables; accent (German and Hungarian) and speaker (first or second), was carried out, and there was a significant interaction between block and sentences, $F(1,78) = 8.06$, $p < .01$, $\eta^2 = .09$, and a significant interaction between block, sentences and accent, $F(1,78) = 8.6$, $p < .01$, $\eta^2 = .1$.

Looking at each block individually, for the baseline block there was a significant effect of sentences, $F1(1,78) = 9.4$, $p < .01$, $\eta^2 =.11$, where reaction times are quicker to the last three sentences compared with the first three (first three sentences average – 851.5, last three sentences average – 805.2). There was no interaction between sentences and group, $F1(1,78) = 1.06$, $p = .32$, $\eta^2 = .01$, and no difference between the groups, $F1(1,78) = 2.67$, $p = .11$, $\eta^2 = .03$. For the foreign accent block there was no significant effect of sentences, $F1(1,78) = 1.11$, $p = .3$, $\eta^2 = .01$ (first three sentences average – 929.7, last three sentences average – 950). There was a significant interaction between sentences and group, $F1(1,78) = 7.65$, $p < .01$, $\eta^2 = .09$, and no difference between the groups, $F1(1,78) < 1$.

Looking at each condition separately, for the German learners there was a significant effect of sentences in the baseline block, $F1(1,40) = 4.64$, $p < .05$, $\eta^2 = .1$ (where reaction times to the last three sentences were quicker than to the first three sentences, first three sentences average – 868.6, last three sentences average – 837.5), and there was no effect of sentences in the foreign accent block, $F1(1,40) = 1.96$, $p = .17$, $\eta^2 = .05$ (first three sentences average – 966.3, last three average – 933.3). For the Hungarian learners there was a significant effect of sentences in the baseline block, $F1(1,40) = 5.31$, $p < .05$, $\eta^2 = .12$ (where reaction times to the last three sentences were quicker compared with the first three sentences, first three sentences average – 834.7, last three sentences average – 773.5), and there was a significant effect of sentences in the foreign accent block, $F1(1,40) = 5.97$, $p < .05$, $\eta^2 = .13$ (where reaction times for the first three sentences were quicker compared with the last three sentences (first three sentences average – 893, last three sentences average – 966.7).

Discussion of Experiment 4

Experiment 4 tested participants with two new foreign accents, German and Hungarian, with the idea to replicate the familiarity effect evidenced in Experiments 1 to 3. German and Hungarian were chosen because they were supposed to be perceptually less distant than French and Malaysian for British ears, even though they carry different levels of familiarity. Results showed that on the overall, RT during the test block were not slower for the Hungarian accent than for the German one. However fine grained analyses within each block revealed that over time, RT in the Hungarian group tended to slow down, whereas they remained stable for the German accent. This pattern resembles that observed in Experiment 1 when comparing French and Malaysian accents: in the second block RT slowed down for the Malaysian learners and remained stable for the French learners. Taken together, this suggests that for an unfamiliar accent, more and more attention is needed so that participants engage all their resources in encoding characteristics. If this is the case,it would be expected that

Hungarian learners would show less errors at the end of the block compared with the beginning because of the increased attention needed to process the accent. However, as was shown in Experiment 1, out of 43 Hungarian learners, 19 had made more errors in the first three sentences of the block compared with the last three sentences, while 13 participants made more errors in the first three sentences (in comparison, out of 42 German learners, 16 made more errors in the last three sentences of the block, and 12 made more errors in the first three sentences).

Discussion of Experiments 1 to 4

So far, the results of Experiments 1 to 4 have shown a broad familiarity effect across the different accents we have looked at (French, Malaysian, German and Hungarian), and this is also possibly superimposed onto a perceptual distance effect, the further the accent is perceptually from our own accent, the bigger the effect. Further evidence of the familiarity effect was shown in fine grained analyses, in that the unfamiliar accent resulted in participants' reaction times slowing down towards the end of the experimental block compared with the beginning (at least in Experiments 1 and 4). It could be that, if participants continued to be exposed to the unfamiliar accent their reaction times would recover. A possible cause of this slowing down when encountering a foreign accent could be due to processing of this accent requiring more attention (although participants have not shown an improvement in the number of errors over the course of the experimental block). Distortion of the speech signal due to a foreign accent would perturb the usual normalisation process, and the process of unfamiliar phonology/acoustics/phonetics would result in a form of "warning alarms" within the processing system. However, some form of long-term normalisation must still occur for unfamiliar accents otherwise all lexical access would be blocked completely, which would mean unfamiliar speech signals would be undecipherable for our processing systems.

The findings of Experiments 1 to 4 suggest that there is a familiarity effect, or a perceptual distance effect, when processing foreign accented speech. However, it is also possible that there are differences between the speakers in terms of how strong their accent is, and it is possible that some speakers have a stronger accent than speakers with a different accent that makes their speech harder to comprehend. One way to try and address this would be to try to determine the "accentedness" of speech. Plomp and Mimpen (1979) developed a test to find the speech reception threshold (SRT) for sentences in quiet and in noise than could be used to assess accentedness. This method presenting a sentence to the listener repeatedly, increasing the sound level until the listener can reproduce the sentence correctly. Then, present the listener with a second sentence, but decrease the level by 2 dB from the level where the first sentence was correctly reproduced. If the second sentence is correctly reproduced, decrease the level by a further 2dB, if it is not increase the level by 2dB. This is repeated for all sentences in the list, and the average presentation level is calculated across the list, and this value is adopted as the SRT for that condition. In order to test the accentedness of the speakers, the SRT could be calculated for each speaker, and the higher the SRT, the stronger the speaker's accent is presumed to be. Using this method, the SRT's for each speaker could be compared to see whether there levels of accentedness were comparable or not.

So far, evidence collected has shown that foreign accents trigger a delay in word identification, and that this delay is modulated by the familiarity of the accent, or perhaps by its perceptual distance to the listeners' phonology. The foreign accent related perturbation extends previous findings from Clarke and Garrett (2004) and Floccia et al., (2006, 2009b). It has also been shown that in some cases, the time-course of this perturbation is not towards a resumption to baseline level, but to a growing disturbance in processing words, as if more and more resources and attention were needed to perform the task. The key question is to understand where this perturbation comes from. Is this due to a longer time required to contact the lexicon because prelexical normalisation is more hazardous, or is it due to comparing the accented form to all those stored in the lexicon in a model such as Johnson (1997)? Alternatively it is possible that as information sent from the prelexical level is not 100 per cent accurate (due to the accent) that lexical activation is not as strong as it would be for non accented words. In other words, are accents related to information stored in the lexicon? One way to try to answer this is to look at how transient the storage of this information might be, which will be looked at in Experiment 5.

Chapter 3

Accent processing in working memory

So far, Experiments 1 to 4 have focused on the long term effects of exposure to accents, and have not been able to facilitate any short term adaptation to accents in a laboratory setting. The next set of experiments aims to investigate how the presence of different accents affects our perceptual systems in the short term, by looking at length of activation of accent-related information in working memory.

Experiment 5: Representation of accent-related information in short term memory

This experiment will evaluate how transient the accent delay effect is in short term memory: when we encounter an accented item, do we keep a trace of the accent features in short term memory after the word has been recognised, or do we discard that information when, or even prior to the word being activated? If the first hypothesis was verified, then it would suggest that indexical information is part of the word identification process. Whereas if the second hypothesis is correct, it would suggest that the accent delay is mainly due to prelexical processes, after which lexical contact and activation are free of indexical information. This will be tested using a cross-modal matching task, where participants will be required to decide whether a spoken word matches a word that is displayed on screen, and a delay/no delay situation will be introduced, in which participants will have to respond immediately or wait 1500 milliseconds before giving their response. If accent information is represented in working memory and in long term memory (in the lexicon), the accent delay would be expected to be evidenced even after 1500 milliseconds. If accent information impairs lexical access but is not used to represent the accessed item, the impairment should not be evidenced after 1500 milliseconds. The cross-modal matching task was introduced in order to measure lexical activation in immediate or delayed condition (note that it was also used by Clarke and Garrett, 2004, but they did not use delayed and no delayed conditions).

Participants

Forty-eight participants (35 female, 13 male) with an average age of 25.75 years were tested in this experiment. Of these participants, 24 were in the no delay condition and 24 were in the delay condition.

Stimuli

Sentences were recorded by several different speakers, who originated from Plymouth, Ireland, France or Malaysia. A regional accent has been introduced to explore the claim according which regional and foreign accents recruit different normalisation mechanisms (Floccia et al., 2006, 2009), and using a regional accent as well as foreign accents will expose any differences in participants responses to regional and foreign accents. Two speakers were used for each accent, and each speaker recorded 10 sentences (Plymouth speakers one and two, both French and both Malaysian speakers from Experiment 1 were used; Irish speaker one – aged 51, born and raised in Cork, Ireland, in Plymouth for 18 years; Irish speaker two – aged 35, born and raised in Dublin, in Plymouth for three years). The results of the accent rating experiment showed the average rating for the Irish accent was 3.27. Including the accent ratings for the Plymouth, French and Malaysian accents, there was a significant overall effect of accent, $F1(3,27) = 8.03$, $p < .01$, $\eta^2 = .47$. Comparing the Irish accent to the other three accents, there was a significant difference between Plymouth and Irish, $F1(1,9) = 16.5$, $p < .01$, $\eta^2 = .65$, and between Irish and Malaysian, $F1(1,9) = 7.34$, $p < .05$, $\eta^2 = .45$, and there was no effect of accent between Irish and French, $F1(1,9) < 1$. For the Irish speakers, the average rating in the accent rating experiment for speaker I1 (3.08) was lower than for speaker I2 (3.46), although this difference was not significant, $t = 1.91$, $df = 9$, $p = .09$. The 95% confidence interval was -.83 to .07, and the effect size was .5. Each sentence was constructed so that the last word of the sentence would remain ambiguous until the word was spoken. The words used at the end of the sentences were selected on the same criteria as used in Experiment 1 (for list of words and their characteristics, see appendix A). For each block of 10 sentences, five were followed by the same word displayed visually as the last word heard and five were followed by a different word to the last word heard. The different words were chosen so that they shared the same first two or three phonemes with the target word, so that the visual word would not be easily identified as different to the last word heard. For example, if the word "buckets" was heard, the word displayed was "buckle", so that the first part of the word is not sufficient to decide if the words are mismatched. This was done to force participants to actually process the entire word and not simply the first letter (example of a match, sentence heard "when Dad came here he always wanted to watch the tennis", word presented on screen "tennis"; example of a mismatch, sentence heard "I really like growing up because I can go to college", word presented on screen "collar").

Procedure

A cross-modal matching task was used in this experiment. Scripts were created and the experiment was controlled using the EPRIME software. Participants were seated at a computer workstation and wore a set of headphones. The experiment was a matched/mismatched design. Participants were instructed to listen to a series of spoken sentences, after which a word would be displayed on screen which either matched or mismatched with the last word heard of the sentence. Participants were required to make a response using the appropriate buttons on the keyboard whether they thought the two words matched or mismatched. All participants heard all 80 sentences (four different accents, two speakers per accent, 10 sentences per speaker). For each participant the order of presentation of sentences was random. This was a between-participants design where participants were allocated into one of two experimental conditions; in the first condition the word was displayed on screen immediately after the end of the spoken sentence, and in the second condition there was a delay of 1500 milliseconds between the end of the spoken sentence and the onset of the word displayed on screen. The word remained on screen for 500 milliseconds, after which participants had a further 1500 milliseconds in which to respond (in total 2000 millisecond after the onset of the word being displayed on screen). Participants responded "match" with their strong hand and responded "no match" with their weak hand, and buttons L and A were used for responses (therefore, right handed participants pressed "L" for a match and "A" for a no-match, left handed participants pressed "A" for a match" and "L" for a no match). After each response participants received feedback, displayed on screen, "correct" if they pressed the correct response, "incorrect" if they pressed the incorrect response (or they wrong key) and "a response was expected" if no button was pushed in the allowed time frame (for incorrect and no responses, a reminder was displayed on screen of which button to push for each type of response). A training phase was presented before the experimental phase, where participants heard eight sentences in an RP (Received Pronunciation) accent, to familiarise them with the task.

Results

Out of 4224 expected responses, 319 were excluded. These were for incorrect or no responses, responses under 200ms or over 2000ms, and all responses under or over 2.5 times the standard deviation of the mean. Out of these incorrect responses, 160 were in the no delay condition, and 159 were in the delay condition. The error scores were analysed to see if there was any differences between the two groups, and between the different accent blocks, and these can be seen in Table 6.

Table 6: *Mean percentage error scores and standard deviations between experimental blocks, broken down into groups.*

	Plymouth accent block		Irish accent block		French accent block		Malaysian accent block	
	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation
No delay group	3.54	4.03	5.63	4.74	6.88	6.73	13.54	5.41
Delay group	5.41	4.64	6.67	5.84	4.79	4.03	12.71	5.89

The error scores were analysed used a repeated measures ANOVA, with one within-participant variable; block (Plymouth, Irish, French and Malaysian accented blocks), and one between-participants variable; group (no delay and delay). There was a significant effect of block, $F1(3,138) = 27.94$, $p < .001$, $\eta^2 = .38$,no difference between the two groups, $F1(1,46) < 1$, , and no interaction between block and group, $F1(3,138) = 1.48$, $p = .22$, $\eta^2 = .03$. The error scores suggest that participants found the Malaysian accented sentences hardest to comprehend, as the mean percentage scores were higher than the other three accent blocks, and as there is no difference between the two groups, whether processing was immediate or delayed did not affect the participants.

Figure 25 shows the mean reaction times for each experimental block, between the two experimental conditions.

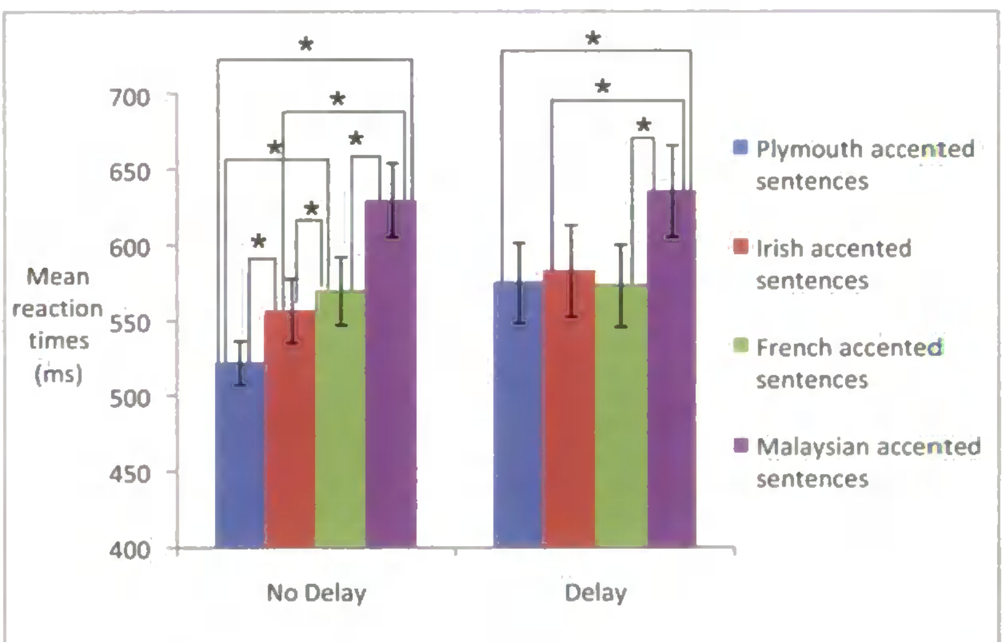

Figure 25: Mean RTs for each experimental blocks, broken down into conditions.

Reaction times were analysed using a repeated measures ANOVA, with three within-participant variables; accent (Plymouth, Irish, French and Malaysian), speaker (two speakers per accent) and response (match and mismatch), and one between-participant variable; condition (delay or no delay). Overall, there was a significant main effect of accent, $F1(3,138) = 44.66$, $p < .001$, $\eta^2 = .49$, $F2(3,24) = 11.76$, $p < .001$, $\eta^2 = .6$, where reaction times were quickest to the Plymouth accent, then to the Irish accent, then the French accent and reaction times were slowest to the Malaysian accent (Plymouth accent average – 548.3; Irish accent average – 570.7; French accent average – 571.4; Malaysian accent average – 632.8). There was no difference between the two conditions by participant, $F1(1,46) < 1$, but there was by item, $F2(1,8) = 16.28$, $p < .01$, $\eta^2 = .67$ (no delay average - 570.19, delay – 591.46). There was a significant difference between response types, $F1(1,46) = 72.737$, $p < .001$, $\eta^2 = .61$, $F2(1,8) = 64.36$, $p < .001$, $\eta^2 = .89$, where responses that were a match were quicker than responses that were a no match (match average – 536.4; no match – 625.2).

The mean differences in reaction times between each of the experiment blocks are shown in Table 7 (no delay condition) and Table 8 (delay condition).

Table 7: *Pairwise comparisons in the no delay condition (* denotes significant mean difference).*

		Mean difference	Standard error
Plymouth	Irish	34.381*	9.139
	French	47.654*	9.644
	Malaysian	109.068*	12.804
Irish	French	13.273*	6.305
	Malaysian	74.697*	10.728
French	Malaysian	61.414*	9.575

Table 8: *Pairwise comparisons in the delay condition (* denotes significant mean difference).*

		Mean difference	Standard error
Plymouth	Irish	8.080	9.347
	French	1.739	11.415
	Malaysian	62.065*	15.133
Irish	French	9.820	8.015
	Malaysian	53.984*	13.436
French	Malaysian	63.804*	10.911

In the no delay condition, there were significant mean differences between all the comparisons, whereas in the delay condition the mean differences between Plymouth and Irish, and Plymouth and French accents were no longer significant, while the differences between Malaysian and the other three accents remained significant.

There was a significant interaction overall between accent and condition by participant, $F1(3,138) = 4.35$, $p < .01$, $\eta^2 = .09$, but not by item, $F2(3,54) < 1$. There was a significant interaction between Plymouth and Irish accents and condition by participant, $F1(1,46) = 4.05$, $p < .05$, $\eta^2 = .19$, but not by item, $F2(1,18) < 1$. The interaction between Plymouth and French accents and condition was also significant by participant, $F1(1,46) = 10.93$, $p < .01$, $\eta^2 = .19$, but not by item, $F2(1,18) = 1.85$, $p = .19$, $\eta^2 = .09$. Finally, the interaction between Plymouth and Malaysian accents and condition was significant by participant, $F1(1,46) = 5.62$, $p < .05$, $\eta^2 = .11$, but not by item, $F2(1,18) = 2.4$, $p = .14$, $\eta^2 = .12$. This last interaction showed that the difference between Plymouth and Malaysian accents decreased over the 1500 ms period, without flattening out as in the Irish and French accents conditions.

Effect of speaker

Figure 26 shows the mean reaction times to each speaker with each experimental block, broken down into experimental groups.

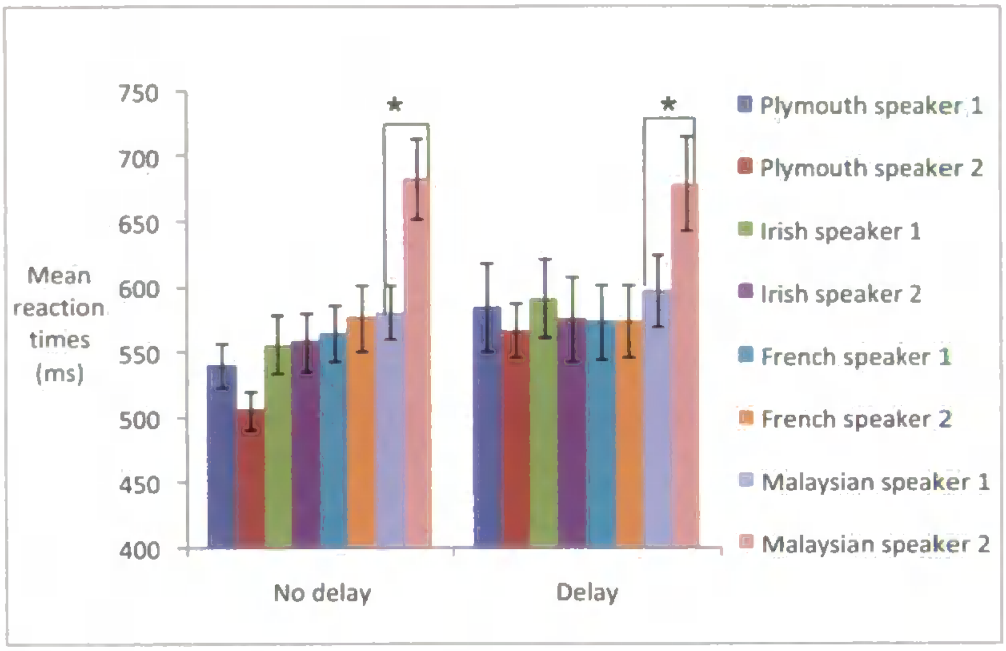

Figure 26: Mean RT's for each speaker, broken down into conditions.

Within the Plymouth accent block, there was a significant effect of speaker by participant, $F1(1,46) = 4.66$, $p < .05$, $\eta^2 = .09$, but not by item, $F2(1,18) = 2.3$, $p = .15$, $\eta^2 = .11$, no interaction between speaker and condition, $F1(1,46) < 1$, $F2(1,18) < 1$, and no effect of condition, $F1(1,46) = 3.08$, $p = .09$, $\eta^2 = .06$, $F2(1,18) = 3.55$, $p = .08$, $\eta^2 = .17$. Within the Irish accent block, there was no effect of speaker, $F1(1,46) < 1$, $F2(1,18) < 1$, no interaction between speaker and condition, $F1(1,46) < 1$, $F2(1,18) <1$, and no effect of condition, $F1(1,46) < 1$, $F2(1,18) = 1.74$, $p = .2$, $\eta^2 = .09$. Within the French accent block, there was no effect of speaker, $F1(1,46) < 1$, $F2(1,18) < 1$, no interaction between speaker and condition, $F1(1,46) < 1$, $F2(1,18) < 1$, and no effect of condition, $F1(1,46) < 1$, $F2(1,18) < 1$. Within the Malaysian block, there was a significant effect of speaker, $F1(1,46) = 47.43$, $p = .001$, $\eta^2 = .51$, $F2(1,18) = 14.27$, $p < .01$, $\eta^2 = .44$, no interaction between speaker and condition, $F1(1,46) < 1$, $F2(1,18) < 1$, and no effect of condition, $F1(1,46) < 1$, $F2(1,18) < 1$.

Discussion of Experiment 5

This experiment investigated how transient the accent delay effect on lexical activation would be, by asking participants to make an immediate cross-modal matching decision (no delay condition) or delay their response by 1500 ms (delay condition). In the no delay condition, the basic accent delay effect was replicated, that is, all accents elicit longer reaction times than the home accent. In addition, the fact that this delay is gradual was also replicated: regional accent (here Irish) elicits faster reaction time than the foreign accents (French and Malaysian) (see also Floccia et al., 2006). In addition, within the foreign accents there was also a familiarity/perceptual distance effect, as found in the previous experiments.

With the delay condition, the results show that the accent delay disappears for the regional and the familiar foreign accent, as participants are just as fast as with the Plymouth accent, but the effect is still there, although weaker, for the Malaysian accent. What this tells us is that 1500 ms after the end of the presentation of the accented word, participants still retain some acoustic information about these words, or they are still processing them, or the level of lexical activation of these words is still low. What it tells us for the Irish and French words though is that 1500 ms after the end of the presentation of the accented words, lexical activation has occurred and no more resources are devoted to processing accent related information, all of which has been discarded. It therefore seems plausible that our speech processing system requires a very short time to effectively normalise accented speech in order to allow for more efficient processing of the speech signal, and that this information is not represented in lexical activation.

The results of Experiment 5 demonstrate that there is a processing cost associated with both regional and foreign accents, and that this cost is affected by the familiarity with the accent. However there are two points that are not clear from these findings. Firstly, it is not clear whether these effects can be generalised to other accents, or whether the effects evident are specific to the accents used in this study. The second question relates to the effect related to the Malaysian accent. It is not clear whether this effect is due to the participants' familiarity, or lack of, with this particularly accent, or whether it is due to the perceptual distance of the Malaysian accent from English phonology. Experiment 6 will attempt to address these questions by introducing different foreign accents, one of which will be rated as familiar to the participants, and one will be rated as unfamiliar.

Experiment 6: Generalising accent related representations in short term memory

Experiment 6 was designed to extend the findings of Experiment 5 with different familiar and unfamiliar foreign accents, German and Hungarian accent groups. As previously discussed, French was classified as a "familiar" foreign accent and Malaysian as an "unfamiliar" foreign accent, it is assumed that German would be a familiar foreign accent to our participants, while Hungarian would be an unfamiliar foreign accent, but perceptually closer than the Malaysian one. For control purposes the Plymouth and Irish accented sentences were retained from Experiment 5.

Participants

Forty-five participants (nine males) with an average age of 20.4 years were tested in this experiment. Out of these participants, 22 were in the no delay condition, and 23 were in the delay condition.

Stimuli

The stimuli used in this experiment were identical to those used in Experiment 5, except the two French speakers were replaced by two German speakers and the two Malaysian speakers were replaced by two Hungarian speakers (the German and Hungarian speakers used were the same as in Experiment 4). The form of the sentences that were recorded and presented to the participants remained the same (see appendix A).

Procedure

The procedure used in this experiment was identical to the procedure used in Experiment 5, except the French and Malaysian speakers were replaced with German and Hungarian speakers.

Results

Out of 3960 expected responses, 310 were excluded. These were for incorrect or no responses, responses under 200ms or over 2000ms, and all responses under or over 2.5 times the standard deviation of the mean. Of these incorrect responses, 153 were in the no delay condition, and 157 were in the delay condition. The error scores were analysed to see if there was any differences between the two groups, and between the different accent blocks, and these can be seen in Table 9.

Table 9: *Mean percentage error scores and standard deviations between experimental blocks, broken down into groups.*

	Plymouth accent block		Irish accent block		German accent block		Hungarian accent block	
	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation
No delay group	7.05	5.27	6.59	6.05	8.18	5.88	8.64	6.58
Delay group	5.22	4.64	9.35	6.09	7.61	5.61	7.82	5.4

The error scores were analysed used a repeated measures ANOVA, with one within-participant variable; block (Plymouth, Irish, German and Hungarian accented blocks), and one between-participants variable; group (no delay and delay). There was no effect of block, $F1(3,129) = 1.61$, $p = .19$, $\eta^2 = ..04$, no difference between the two groups, $F1(1,43) < 1$, , and no interaction between block and group, $F1(3,129) = 1.72$, $p = .17$, $\eta^2 = ..04$. The error scores suggest that all participants found each accent group similarly difficult to comprehend, with no difference evident between the two groups.

Figure 27 shows the mean reaction times for each experimental block, between the two experimental conditions

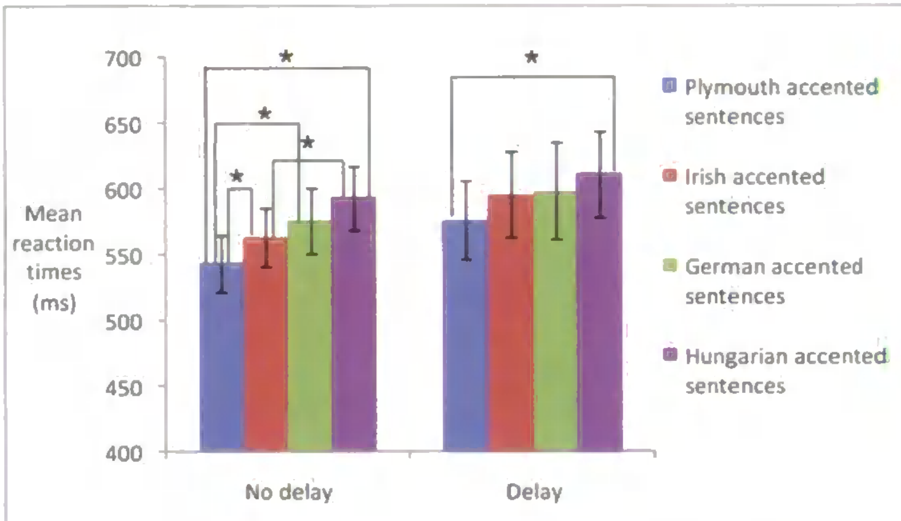

Figure 27: Mean RT's for each experimental blocks, broken down into conditions.

Reaction times were analysed using a repeated measures ANOVA, with three within-participant variables; accent (Plymouth, Irish, German and Hungarian), speaker (two speakers per accent) and response (match or no match), and one between-participant variable; condition (delay or no delay). There was a significant main effect of accent, $F1(3,129) = 9.59$, $p < .001$, $\eta^2 = .18$, $F2(3,24) = 5.84$, $p < .01$, $\eta^2 = .42$, where reaction times were quickest to the Plymouth accent, followed by the Irish accent, then the German accent with slowest reaction times to the Hugarian accent (Plymouth accent average – 559.6; Irish accent average – 580; German accent average – 586.6; Hungarian accent average – 600.5). There was no difference between the two conditions, $F1(1,43) < 1$, $F2(1,8) = 4.03$, $p = .08$, $\eta^2 = .34$ (no delay average – 568.8, delay average – 594.6). There was a significant effect of response types, $F1(1,43) = 103.12$, $p < .001$, $\eta^2 = .71$, $F2(1,8) = 54.43$, $p < .001$, $\eta^2 = .87$, where responses that were a match were quicker than responses that were a no match (match average – 535.5, no match average – 627.8).

The mean differences in reaction times between each of the experiment blocks are shown in Table 10 (no delay condition) and Table 11 (delay condition).

Table 10: *Pairwise comparisons in the no delay condition (* denotes significant mean difference).*

		Mean difference	Standard error
Plymouth	Irish	18.885*	7.825
	German	33.446*	9.505
	Hungarian	48.868*	11.319
Irish	German	14.561	11.016
	Hungarian	29.983*	11.297
German	Hungarian	15.423	8.296

Table 11: *Pairwise comparisons in the delay condition (* denotes significant mean difference).*

		Mean difference	Standard error
Plymouth	Irish	18.935	11.657
	German	22.107	11.994
	Hungarian	33.924*	8.098
Irish	German	3.172	12.583
	Hungarian	14.989	10.451
German	Hungarian	11.817	12.177

In the no delay condition, there were significant mean differences between all the comparisons except between Irish and German, whereas in the delay condition the only comparison that remained significant is between Plymouth and Hungarian, all other comparisons were not significant.

However, statistical comparisons for this experiment are less informative. There was no interaction overall between accent and condition, $F1(3,129) < 1$, $F2(3,54) < 1$. There was no interaction between accents (Plymouth and Irish) and condition, $F1(1,43) < 1$, $F2(1,18) < 1$, between accents (Plymouth and German) and condition, $F1(1,43) < 1$, $F2(1,18) < 1$, between accents (Plymouth and Hungarian) and condition, $F1(1,43) = 1.17$, $p = .29$, $\eta^2 = .03$, $F2(1,18) < 1$, between accents (Irish and German) and condition, $F1(1,43) < 1$, $F2(1,18) < 1$, between accents (Irish and Hungarian) and condition, $F1(1,43) < 1$, $F2(1,18) < 1$, or between accents (German and Hungarian) and condition, $F1(1,43) < 1$, $F2(1,18) < 1$.

Effect of speaker

Figure 28 shows the mean reaction times to each speaker with each experimental block, broken down into experimental groups.

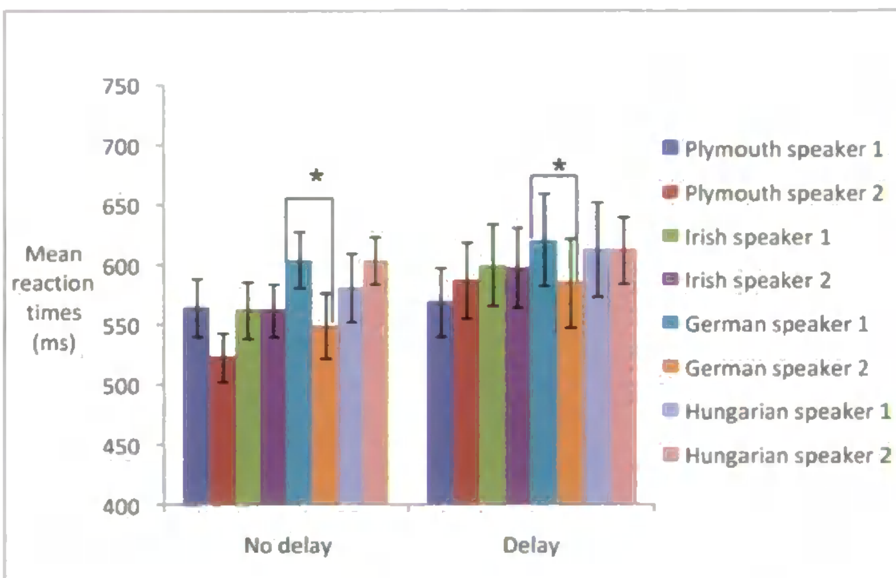

Figure 28: Mean RT's for each speaker, broken down into conditions.

Within the Plymouth accent block, there was no effect of speaker, $F1(1,43) = 2.37$, $p = .13$, $\eta^2 = .05$, $F2(1,18) < 1$, a significant interaction between speaker and condition by participant, $F1(1,43) = 11.33$, $p < .01$, $\eta^2 = .21$, but not by item, $F2(1,18) = 2$, $p = .17$, $\eta^2 = .1$, and no effect of condition, $F1(1,43) < 1$, $F2(1,18) = 1.46$, $p = .24$, $\eta^2 = .08$. Within the Irish accent block, there was no effect of speaker, $F1(1,43) < 1$, $F2(1,18) <$

1, no interaction between speaker and condition, $F1(1,43) < 1$, $F2(1,18) < 1$, and no effect of condition, $F1(1,43) < 1$, $F2(1,18) = 3.97$, $p = .06$, $\eta^2 = .18$. Within the German accent block, there was a significant effect of speaker by participant, $F1(1,43) = 18.01$, $p < .001$, $\eta^2 = .3$, but not by item, $F2(1,18) = 3.2$, $p = .09$, $\eta^2 = .15$, no interaction between speaker and condition, $F1(1,43) < 1$, $F2(1,18) < 1$, and no effect of condition, $F1(1,43) < 1$, $F2(1,18) < 1$. Within the Hungarian block, there was no effect of speaker, $F1(1,43) < 1$, $F2(1,18) < 1$, no interaction between speaker and condition, $F1(1,43) < 1$, $F2(1,18) < 1$, and no effect of condition, $F1(1,43) < 1$, $F2(1,18) < 1$.

Discussion of Experiment 6

The results of Experiment 6 seem to lend further support to the results of Experiment 5, where the accent effect was only present in the no delay condition. It would seem therefore that the findings can be generalised to other accent groups. It should be noted that, although pairwise comparisons between accents yield similar results, especially when comparing responses to the Plymouth accent to responses given to any other regional or foreign accent, the overall interaction between condition (delay versus no delay) and accents are not significant in this experiment, as they were in Experiment 5. However, the interactions tended to be significant by participant not by item, which could be due to certain sentences carrying more accent related information than others, and as such those sentences lend themselves to accent related effects.

Experiment 7: Accent related information in non-words

So far, Experiments 5 and 6 seem to have shown that we are able to normalise the accented speech signal and eliminate the accent effect within a very short period of time (1500 milliseconds) when the lexicon has been contacted. This may be because we are able to compare the accented speech to stored representations of previously encountered words in our memory and so we can access a normalised version of what we are hearing. But what if we did not have a stored phonological representation of words in our memory to compare with accented speech? To try to address this, Experiment 7 has been designed using made up, nonwords, which participants will not have encountered previously and for which they will not have stored representations to compare to accented speech. If the flattening of the word identification cost in the delay condition found in Experiments 5 and 6 was due to participants having retrieved abstract phonological representations in their lexicon, then such a flattening should not be observed in Experiment 7 with non-words. If however this flattening was due to prelexical normalisation having occurred before the word was compared with representations stored in the lexicon, then a similar flattening should be observed also in Experiment 7.

Participants

Fifty-three participants (40 female, 13 male) with an average age of 20.04 took part in this experiment. Out of these participants, 26 were in the no delay condition, and 27 were in the delay condition.

Stimuli

The six Irish, German and Hungarian speakers used in Experiment 6 were used in this experiment (two of each accent). In addition two new Plymouth speakers were also used to record new sentences (speaker one, aged 36, born and raised in Plymouth; speaker two, aged 42, born and raised in Plymouth). The accent rating experiment showed the average rating for the Plymouth accent was 2.59. Comparing all four accents used in this experiment, there was a significant overall effect of accent, $F1(3,27) = 4.66$, $p < .05$, $\eta^2 = .34$. Comparing the accents with each other, there was a significant difference between Plymouth and Irish, $F1(1,9) = 16.5$, $p < .01$, $\eta^2 = .65$, and between Irish and German, $F1(1,9) = 8.22$, $p < .05$, $\eta^2 = .48$. There was no effect of accent between Plymouth and German, $F1(1,9) < 1$, between Plymouth and Hungarian, $F1(1,9) < 1$, between Irish and Hungarian, $F1(1,9) = 4.7$, $p = .06$, $\eta^2 = .34$, and between German and Hungarian, $F1(1,9) = 1.35$, $p = .28$, $\eta^2 = .13$. For the new Plymouth speakers, the average rating in the accent rating experiment for speaker PL1

(2.64) was significantly lower than for speaker PL2 (3.46), $t = 2.64$, $df = 9$, $p < .05$. The 95% confidence interval was -1.52 to -.12, and the effect size was 1.4. New sentences were constructed (in the same way as the sentences in Experiments 5 and 6) and recorded by the speakers (see appendix). Instead of ending with a word, all sentences used in this experiment ended with a made up, non-word (see appendix A). Non-words were selected on the same criteria as was used to select non-words in Experiment 1.

Procedure

The procedure used in this experiment was identical to the procedure used in Experiment 6, except the sentences that were presented to the participants were different (ending with non-words). Participants' task again was to decide whether or not the ending non-word matched the visually presented item. As in the previous experiments, participants were presented with a training phase first, which consisted of eight sentences presented in a RP accent, all ending with non-words, constructed in the same way as the sentences used in the test phase.

Results

Out of 4664 expected responses, 681 were excluded. These were for incorrect or no responses, responses under 200ms or over 2000 ms, and all responses under or over 2.5 times the standard deviation of the mean. Of these incorrect responses, 329 were in the no delay condition, and 352 were in the delay condition. The error scores were analysed to see if there was any differences between the two groups, and between the different accent blocks, and these can be seen in Table 12.

Table 12: *Mean percentage error scores and standard deviations between experimental blocks, broken down into groups.*

	Plymouth accent block		Irish accent block		German accent block		Hungarian accent block	
	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation	Mean percentage errors (%)	Standard deviation
No delay group	8.65	5.58	11.54	6.6	20.19	4.99	14.23	6.11
Delay group	10	6.5	13.33	8.44	22.22	8.24	14.81	7.66

The error scores were analysed used a repeated measures ANOVA, with one within-participant variable; block (Plymouth, Irish, German and Hungarian accented blocks), and one between-participants variable; group (no delay and delay). There was a significant effect of block, $F1(3,153) = 35.58$, $p < .001$, $\eta^2 = .41$, where error scores were higher for German accented sentences, then to Hungarian accented sentences, then to Irish accented sentences, and finally to Plymouth accented sentences. There was no difference between the two groups, $F1(1,51) = 1.44$, $p = .24$, $\eta^2 = .03$, and no interaction between block and group, $F1(3,153) < 1$. The error scores suggest that the participants found the foreign accent blocks most difficult to comprehend, and in fact found German accented sentences more difficult than Hungarian accented sentences.

Figure 29 shows the mean reaction times for each experimental block, between the two experimental conditions.

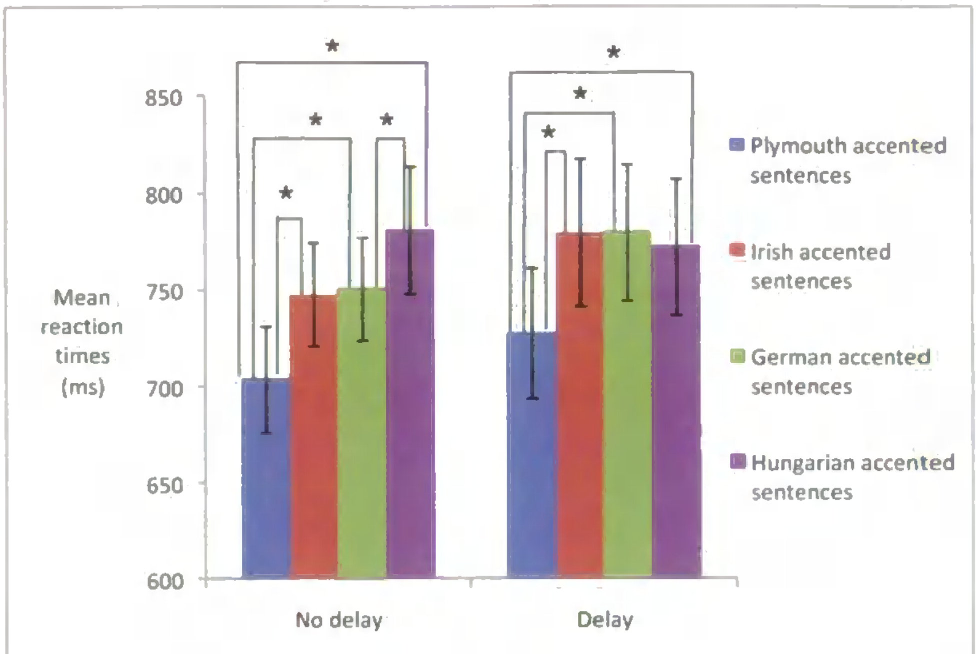

Figure 29: Mean RT's for each experimental blocks, broken down into conditions.

Reaction times were analysed using a repeated measures ANOVA, with three within-participant variables; accent (Plymouth, Irish, German and Hungarian), speaker (two speakers per accent) and response (match and no match), and one between-participant variable; condition (delay or no delay). There was a significant main effect of accent by participant, $F1(3,153) = 17.85$, $p < .001$, $\eta^2 = .26$, but not by item, $F2(3,21) = 2.51$, $p = .09$, $\eta^2 = .26$, where reaction times were quickest to the Plymouth accent, then to the German accent, followed by the Irish accent, with slowest reaction times to the Hungarian accent (Plymouth accent average – 719.3, Irish accent average – 770.9, German accent average – 767.6, Hungarian accent average – 776.7). There was no difference between the two conditions, $F1(1,51) <1$, $F2(1,7) = 1.87$, $p = .21$, $\eta^2 = .21$. There was a significant effect of response types, $F1(1,51) = 86.03$, $p < .001$, $\eta^2 = .63$, $F2(1,7) = 46.93$, $p < .001$, $\eta^2 = .87$, where reaction times were quicker to the match response than to the no match response (match average - 714.1, no match response – 803.2).

The mean differences in reaction times between each of the experimental blocks are shown in Table 13 (no delay condition) and Table 14 (delay condition).

Table 13: *Pairwise comparisons in the no delay condition (* denotes significant mean difference).*

		Mean difference	Standard error
Plymouth	Irish	45.151*	10.716
	German	49.709*	10.388
	Hungarian	79.457*	10.982
Irish	German	4.558	13.262
	Hungarian	34.305	16.899
German	Hungarian	29.747*	10.318

Table 14: *Pairwise comparisons in the delay condition (* denotes significant mean difference).*

		Mean difference	Standard error
Plymouth	Irish	54.447*	16.379
	German	53.251*	14.473
	Hungarian	45.678*	12.288
Irish	German	1.197	10.607
	Hungarian	8.769	11.056
German	Hungarian	7.573	9.501

There was no overall interaction between accent and condition, $F1(3,153) = 2.42$, $p = .07$, $\eta^2 = .05$, $F2(3,51) < 1$. There was a significant interaction between accents (Plymouth and Hungarian) and condition by participant, $F1(1,51) = 4.18$, $p < .05$, $\eta^2 = .08$, but not by item, $F2(1,18) < 1$, between accents (Irish and Hungarian) and condition by participant, $F1(1,51) = 4.62$, $p < .05$, $\eta^2 = .08$, but not by item, $F2(1,18) = 1.55$, $p = .23$, $\eta^2 = .08$, and between accents (German and Hungarian) and condition by participant, $F1(1, 51) = 7.1$, $p < .01$, $\eta^2 = .12$, but not by item, $F2(1,17) = 1.19$, $p = .29$, $\eta^2 = .07$. There was no interaction between accents (Plymouth and Irish) and condition, F1(1,51) < 1, F2(1,18) < 1, between accents (Plymouth and German) and condition, F1(1,51) < 1, F2(1,18) < 1, and between accents (Irish and German) and condition, F1(1,51) < 1, F2(1,17) < 1.

Figure 30 shows the mean reaction times to each speaker within each experimental block, broken down into experimental groups.

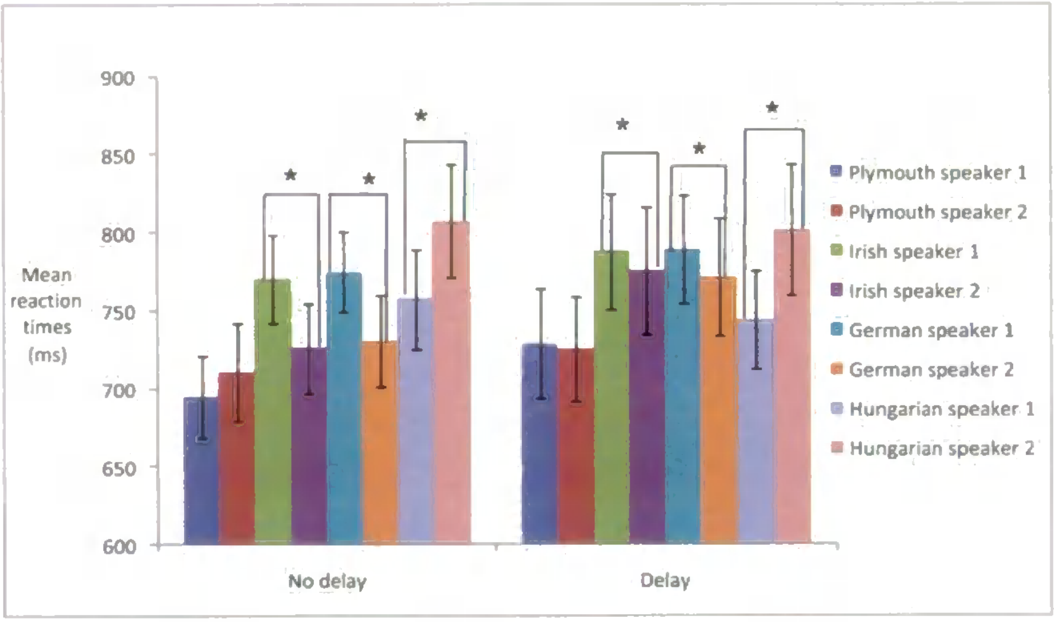

Figure 30: Mean RT's for each speaker, broken down into conditions.

Within the Plymouth accent block, there was no effect of speaker, F1(1,51) < 1, F2(1,18) = 1.24, p = .28, η^2 = .06, no interaction between speaker and condition, F1(1,51) < 1, F2(1,18) < 1, and no effect of condition, F1(1,51) < 1, F2(1,18) < 1. Within the Irish accent block, there was a significant effect of speaker by participant, F1(1,51) = 4.29, p < .05, η^2 = .08, but not by item, F2(1,18) = 3.98, p = .06, η^2 = .18, no interaction between speaker and condition, F1(1,51) = 1.34, p = .24, η^2 = .03, F2(1,18) < 1, and no effect of condition, F1(1,51) < 1, F2(1,18) < 1. Within the German accent condition, there was a significant effect of speaker by participant, F1(1,51) = 10.04, p < .01, η^2 = .17, but not by item, F2(1,17) = 2.84, p = .11, η^2 = .14, no interaction between speaker and condition, F1(1,51) = 1.89, p = .18, η^2 = .04, F2(1,17) < 1, and no effect of condition, F1(1,51) < 1, F2(1,17) = 1.19, p = .29, η^2 = .07. Within the Hungarian accent condition, there was a significant effect of speaker, $F1(1,51) = 15.89$, $p < .001$, $\eta^2 = .24$, $F2(1,18) = 14.27$, $p < .01$, $\eta^2 = .44$, no interaction between speaker and condition, $F1(1,51) < 1$, $F2(1,18) < 1$, and no effect of condition, $F1(1,51) < 1$, $F2(1,18) < 1$.

Discussion of Experiment 7

The results of Experiment 7 show that, as predicted by any model of speech perception, in the no delay condition, the effect of accent is still present when using nonwords instead of real words. However, the main difference between this experiment and Experiments 5 and 6 is that most of the significant differences present in the no delay condition do not "disappear" in the delay condition as they did in the experiments using real words. Instead, the accent effects between Plymouth and Irish, and between Plymouth and German, are still of the same magnitude in the no-delay and delay condition. This suggests that, during the delay period, participants are not able to normalise the speech signal that they are hearing because they do not have a stored representation of the nonword to compare, and so the accent effect remains even after the delay.

In contrast, the accent effect between Plymouth and Hungarian was significantly reduced in the delay condition as compared with the no-delay condition, however the delay elicited by the Hungarian accent still remained very high in both conditions. It could suggest that some acoustic accent-related information is discarded over time, leading to a more normalised representation, however these results taken together strongly suggest that indexical information related to accents can be represented in working memory.

Chapter 4

General Discussion of Adult Studies

This study aimed to examine the conditions under which short-term and long-term adaptation to regional and foreign accents could be obtained. Experiment 1 examined short and long-term adaptation to familiar (French) and unfamiliar (Malaysian) foreign accents by using a lexical decision task in two sessions, one week apart. In the first session participants heard examples of their own, baseline, accent, and either the familiar or unfamiliar accent. In the second session, they heard both foreign accents. Overall, a long-term effect of familiarity, or perceptual distance, was found in week one, where reaction times were quicker to the familiar over the unfamiliar accent. However there was no evidence of short term adaptation to the unfamiliar accent, with reaction times actually slowing down with repeated exposure, possibly due to more attention being engaged to process the unfamiliar accent. There appeared to be some evidence for long-term adaptation in week two, with exposure to the accent in week one leading to improved reaction times over those participants who were not exposed to the same accent in week one, however these improvements were not significant.

It is possible that the lack of short term adaptation in week one was due to insufficient exposure to the unfamiliar accent. Experiment 2 attempted to address this by presenting the participants with a couple of minutes of natural accented speech (a speaker telling a story) before using the same lexical decision task as in session one of Experiment 1. The accent of the natural speech was the same as the foreign accent block (i.e. French accented passage, followed by French accented sentences). In addition to providing more exposure to the foreign accents, this passage would provide exposure to more naturally produced speech, which could aid short-term adaptation. It was found that reaction times to the unfamiliar foreign accented sentences were still slower than to the familiar accent, and that the additional exposure was not sufficient to lead to adaptation to the unfamiliar accent.

The participants in Experiment 2 were instructed to listen carefully to the passage in case they were tested on it later. It is possible that participants engaged more attention to the content of the passage rather than simply listening (and potentially adapting) to the accent, which could have negated any short-term adaptation. Experiment 3 was identical to Experiment 2 except that the instructions were changed to "please relax and listen to the following passage", to investigate whether adaptation effects could be uncovered. The findings were similar to those of Experiment 2, and again short-term adaptation effects were not found.

In order to investigate whether the familiarity, or perceptual distance, effects found in Experiments 1 to 3 could be generalised, new familiar (German) and unfamiliar (Hungarian) foreign accents were introduced in Experiment 4. The first session from Experiment 1 was replicated with these new accents, and found that, although reaction times between the two accents were not statistically different, the Hungarian group demonstrated reaction times that slowed down with repeated exposure, similar to the pattern shown in Experiment 1. Therefore the only robust effect that can be reported in these first four studies is an initial perturbation associated with the presentation of an unfamiliar – or perceptually distant – foreign accent.

Given the outcome of these first four experiments, an attempt was made to investigate where this initial perturbation comes from. Experiment 5 used a cross modal matching task where a spoken sentence was heard followed by a word displayed visually on screen, and participants were required to decide whether the last word of the sentence matched the word on screen. Here a regional accent (Irish) was introduced in addition to the familiar (French) and unfamiliar (Malaysian) foreign accents to explore the claim that regional and foreign accents recruit different normalisation mechanisms (Floccia et al., 2006, 2009b). The word was presented either immediately after the sentences was heard or after a delay of 1500 milliseconds after the end of the spoken sentence. The rationale was that, if accent information impairs lexical access but is not represented in the lexicon, then any impairment should not be evident after the short delay. The results replicated the basic accent effect (initial perturbation) in the no delay condition, however in the delay condition the accent effect disappeared for the regional and familiar foreign accent, but not for the unfamiliar foreign accent. Experiment 6 attempted to replicate these findings with another pair of familiar/unfamiliar foreign accents (German and Hungarian), however, although the pairwise comparisons yielded similar results, the overall effect was not significant by item, which could be due to the sentences carrying less accent related information for the German and Hungarian accents than they did for the French and Malaysian accents.

Experiment 7 attempted to extend the findings of Experiments 5 and 6 by using nonwords instead of real words. The idea was to examine what would happen when we do not have a stored lexical representation available to compare to the accented speech. The results of this experiment showed the same accent effect in the no delay condition as the previous experiments, however this time most of these effects did not disappear in the delay condition, suggesting that normalisation was not possible with nonwords because there was no stored representation to compare against.

Overall, this study has found evidence of impairments in speech perception caused by the presence of different regional and foreign accents. It has shown that this impairment can be discarded quickly (within 1500 milliseconds) when words can be recognised by comparison to the lexicon, but remains when the words (or, as in this case non words) are not represented in the lexicon. This means that automatic normalisation of the acoustic signal does not occur quickly, and is dependent on the task. It has also shown that the amount of exposure present in the tasks used did not provide sufficient time for adaptation of this impairment to occur, as revealed by the lack of adaptation in Experiments 1 to 4. However, adaptation to an accent must be possible in the long term because evidence of accent familiarity is provided (as shown again in Experiments 1 to 4).

These findings are consistent with some other studies that have attempted to show adaptation to an accent. Adank and McQueen (2007) attempted to provoke adaptation through exposure to 20 minutes of regionally accented speech, with an animacy task used to assess any adaptation effects. They found that this exposure was not sufficient, although their use of a distracter task following the exposure to spontaneous speech could have contributed to the lack of any adaptation effects. However, this was addressed in Experiment 3 by instructing participants to simply relax and listen to the passage, but still adaptation effects were not evidenced (see also Floccia et al., 2009b for a failure to report any adaptation to regional and foreign accented sentences). However, the familiarity effect in Experiments 1 to 4 suggests that, in contrast to these findings, adaptation to an accent is possible in the long term. However, other attempts to report adaptation to accents have been successful. Norris, McQueen and Cutler (2003) demonstrated that Dutch listeners were able to use lexical information in order to successfully categorise ambiguous sounds within a laboratory setting. Participants were presented with words where the final fricative was replaced with an ambiguous sound between [f] and [s]. One group heard the ambiguous sound added to [f] final words and also heard unambiguous [s] final words, while the other group heard the opposite (ambiguous [s] final and unambiguous [f] final words). They found that participants who had heard the ambiguous sound in [f] final words were more likely to categorise subsequent ambiguous sounds on an [f] – [s] continuum as [f]. What this study seems to suggest is that the lexicon sends a training signal to the prelexical levels, which can modify the processing of subsequent new information. This training signal would be built up through exposure over time. My findings, particularly those of Experiments 1 and 4 lend further support to this notion of a training signal. In those experiments, reaction times to the unfamiliar foreign accent (Malaysian in Experiment 1 and Hungarian in Experiment 4) became longer over time in the test blocks, whereas reaction times to the presumably more familiar foreign accent (French in Experiment 1 and German in Experiment 4) remained relatively stable over time. Using Norris et al.'s proposal of a training signal, reaction times to the familiar accent remained stable because a training signal had already been developed through years of exposure, whereas no training signal yet exists for the unfamiliar accent, and the development of which requires more and more attention during processing, which ultimately leads to the training signal. This could explain why reaction times to the unfamiliar accent increased as the amount of exposure increased.

Clarke and Garrett (2004) suggest that as little as one minute of exposure to accented speech is sufficient for adaptation to occur. This study was not able to produce a similar effect of exposure and in fact the results suggest that, rather than adaptation occurring quickly with a relatively short amount of exposure, adaptation to an accent is built up over a longer period of exposure, and as such results in a familiarity effect for accents where exposure has previously occurred over time.

The findings of Experiments 5 and 6 seem to demonstrate that our perceptual system is able to normalise accented speech in a relatively short amount of time (1500 milliseconds), which results in eliminating the accent effect evident when processing is immediate. However, McLennan and Luce (2005) reported an effect of talker identity in a shadowing task (experiment 3) only when there was a delay before a response was made. Participants were required to repeat a disyllabic sequence, presented through headphones, and they were presented with two blocks of trials, the first block made up of the prime words and the second block made up of the target words. The stimuli were produced by a male and a female talker, and words were either matched or mismatched between the prime and target words (matched words were produced by the same talker, mismatched words produced by both speakers). They found that when participants were required to respond immediately there was no difference in responses to matched and mismatched words, however when a delay of 150 milliseconds was introduced before the response, they found an effect of talker identity, with responses to the matched words significantly quicker than to mismatched words. These findings would appear to be in contrast to my findings, where an effect of accent in the no delay condition was found, whereas some of the accent effects were eliminated in the delay condition. The difference between my findings and McLennan and Luce's in the delay condition could be explained in the length of the delay, they only delayed processing for 150 ms whereas our participants were delayed for 1500 ms before a response was expected. Perhaps after 150 ms our perceptual systems is still processing indexical information, and so processing costs are evident, whereas 1500 ms may allow enough time to more fully processing indexical information. With regards to the effects observed in the delay / no delay conditions, McLennan and Luce suggest that during the early stages of perceptual processing more abstract or underlying features dominate, whereas during later stages of processing, more specific, detailed surface information dominates. My results, however, suggest that accent related indexical information has an effect in the early stages of processing. Perhaps our perceptual systems find it easier to ignore surface variations such as speaking rate and talker identity (male/female) as investigated by McLennan and Luce, whereas accent information provides a more difficult processing challenge. Indeed talker identity and speech rate variations require the listener to abstract well-known phonological forms from noisy signal, whereas accent-related variations require the listener to represent new phonological forms and assimilate them to what is known.

Further evidence that the effect of accent related indexical information is dependent upon the task can be seen in a study by Shah and McLennan (forthcoming). They presented participants with sentences spoken by native and non-native speakers and were asked to rate the degree of accentedness of the final word of each sentence. The final word was either obvious from the sentence context, or was unexpected from the context. There was a 500 millisecond delay between the final word and the rest of the sentence, and ratings were made on a scale of one to seven. As well as the ratings, reaction times were also recorded. They found that ratings were made quicker for the native speaker over the non native speaker in the condition where the final word was obvious from the sentence context, while the native speaker was rated as weaker than the non native speaker, regardless of condition. What these results show is that our impression of accentedness is directly affected by the ease with which we are able to process the speech we are exposed to. This relates to the findings of Experiments 5 and 6, in that when the participants' processing systems were not given time to eliminate accent information from the speech signal (the no delay condition), the accent effect was evident. This could be seen as "difficult" processing, because a response was required immediately, whereas the no delay condition allowed the processing system time to deal with the accent information, so could be classed as "easy" processing (see also McLennan and Luce, 2005 for the same argument). Therefore the accent effect was evident only when processing was "difficult".

There are other factors that may contribute to the findings of these studies. The first factor relates to the differences between speakers. The effects that have been attributed to accents (and the participants familiarity with those accents), could also be due to the speakers' fluency of the language. It is possible that, rather than the effects being caused by the accent of the speaker, it could in fact be due to the speakers proficiency with English. Some foreign accented speakers may be harder to understand because they are less fluent with English, and so the comprehensibility of their speech is affected by this. It is possible that a foreign accented speaker with a very strong accent, but who is very fluent in English, is easier to comprehend than a speaker with a less strong accent but who is not as fluent in English.

The second factor that could have affected the findings of the studies relates to the counterbalancing of the sentences, particularly in Experiment 1, and Experiments 5 to 7. In Experiment 1, where participants were tested in two sessions one week apart, the sentences were different between the two sessions in order to prevent the participants from simply remembering the test items from the first session. However, this was not counterbalanced between the two sessions, so all participants heard the same sentences in session one and in session two. Although the sentences themselves were constructed to be similar in length and number of syllables, and the target words and non-words were controlled for similarity in terms of phonological neighbours and frequency (for words), the absence of counterbalancing means that it is not possible to completely rule out effects of the sentences themselves. It is possible, for example, that sentences in session two carried more accent related information, and as such made them more difficult to comprehend than those used in session one. This could mean that the lack of adaptation to the accent between the two sessions was due to the sentences used rather than an inability to adapt to the accent. Similarly, the sentences used in Experiments 5 to 7 were not counterbalanced across accents, so again it is not possible to completely rule out the effects were found were due to differences between sentences, rather than accent differences between speakers.

The findings of these experiments seems to lend support to the assumption of most models of speech perception that a process of accent normalisation takes place at the prelexical level, and that accent information would not therefore be represented in the lexicon. If this was not the case, and accent information was represented, an effect of accent in the delay condition in Experiments 5 and 6 would be expected. However, the results show that the accent effect found in the no delay condition is eliminated in the 1500 ms delay, during which time is it conceivable that accent normalisation is taking place. However, the accent effect did not disappear for all the accents used in these experiments, in particular the unfamiliar Malaysian accent used in Experiment 5 elicited significantly longer reaction times than all the other accents in the delay condition as well as the no delay condition, suggesting that accent normalisation had not occurred for this accent. Perhaps the reason for this could be that, because of the unfamiliar nature of this accent to the participants, this accent was so "alien" that words were treated as non-words, which resulted in more time for the correct word candidate to be retrieved because they were required to guess the word with top-down information. This is supported by the results of Experiment 7 using non-words, where the effect of accent was found in the delay condition as well (between Plymouth/Irish, Plymouth German and Plymouth/Hungarian accents).

These findings seem to support the idea of a normalisation process at the prelexical level in speech perception. The question is how does this normalisation process work, and how can the differences in processing familiar and unfamiliar accents be explained? Perhaps, when we encounter an accent through natural exposure, our perceptual system builds a training signal to this accent (Norris et al., 2003), so that, when we encounter this accent in the future, the lexicon is able to send this training signal to the prelexical stage in order to process the accented speech. This would explain the discrepancy between familiar and unfamiliar accents in that the perceptual systems of the participants in these experiments had not been sufficiently exposed to the unfamiliar (Malaysian and Hungarian) accents to have built up a training signal, whereas long term exposure (e.g. learning languages at school, the media) to the familiar (French and German) accents had allowed a training signal to develop. In the case of the unfamiliar accents, because there is no training signal available, more and more attention is required to, not only process the accented speech, but also learn a new accent model for this unfamiliar accent, which over time will ultimately lead to a training signal for this accent. This increased attention can especially be seen in Experiments 1 and 4, where responses at the end of the experimental block had got slower compared with responses at the beginning of the block, suggesting that participants were devoting more attentional resources to the processing of the speech signal. Figure 31 shows the Accent Training Procedure (ATP) model, which has been developed to attempt to explain how this works.

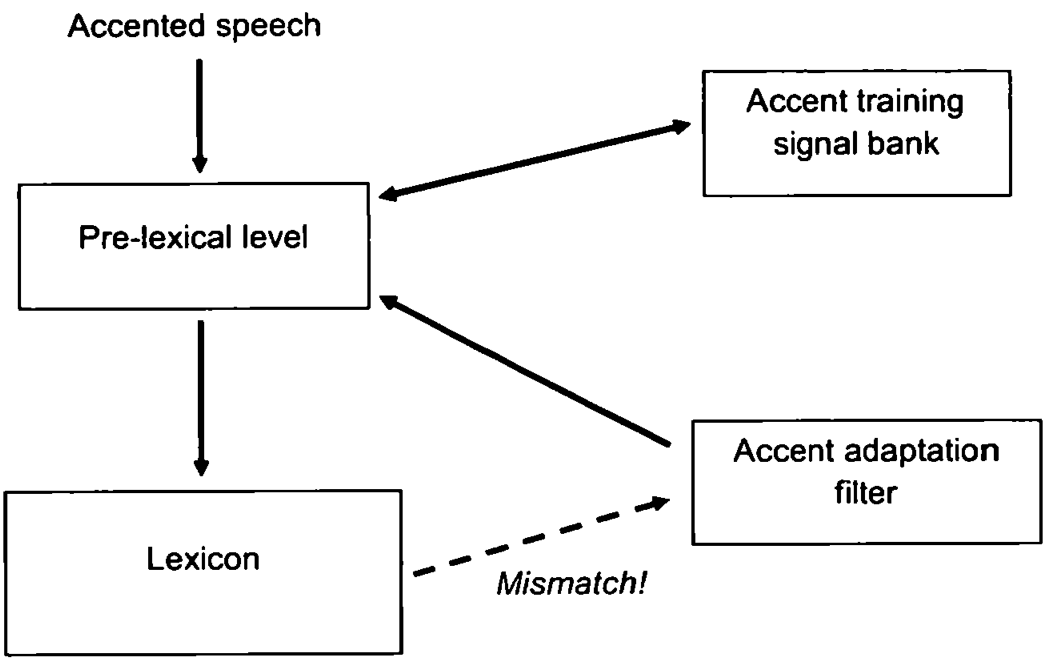

Figure 31: Accent Training Procedure (ATP) Model of how accent related indexical information in processed in the speech processing system

In this model, when accented speech is encountered, it will be processed (as normal speech) at the prelexical level. Once processed, the speech is then compared with the lexicon. If there is a mismatch, it is then sent to the accent adaptation filter, to be compared with any saved accent templates. These templates will have been built up through previous exposure to the particular accent, and, if a template is found, the speech can then be processed and sent back to the lexicon for word identification. If the accent has not been previously encountered (or previous exposure has been insufficient to build up a template), then the accent information is then sent to the accent training signal bank. Here the accent information is collated and, once sufficient information about a particular accent has been collated, a new accent template can be sent to the accent adaptation filter. In this way, processing of a familiar accent will be quicker than processing an unfamiliar accent because unfamiliar accented speech will need to be processed by both the accent adaptation filter and the accent training signal bank, as well as requiring greater resources to identify the correct word. In relation to familiar accented speech, this could explain why processing of familiar accented speech is still slower than processing speech in our native accent, because the accent adaptation filter still needs to be accessed after a mismatch signal sent by the lexicon.

This model allows us to make predictions as to how the comprehensibility of accented speech is affected by a listeners' previous experience with the particular accent. When a listener encounters a new accent, comprehensibility of that accented speech will be most severely affected. This is because the listener has not had any previous exposure in order to develop an accent template that can be utilised in order to process the accented speech in order to find a match in the lexicon. The comprehensibility of this new accented speech is further impaired due to the necessity of other mechanisms (such as context) in order to find a match, as well as the greater cognitive load due to the development of a new accent template.

Once the listener has accumulated sufficient exposure to an accent to have developed an accent template, we would expect comprehensibility of that accent to have improved compared with the comprehensibility of the accent prior to exposure. However, the findings of Experiments 1 to 4 suggest that comprehensibility to an accent does not improve to the level of the listeners' home accent. Therefore this model would predict that processing of accented speech is impaired in terms of comprehensibility, and through exposure to an accent, this impairment can be reduced (but not eliminated). What is not clear is the amount of exposure necessary for an accent template to be developed, as the findings of Experiments 1 to 4, and previous research (e.g. Adank and McQueen, 2007; Floccia et al., 2009a) suggest that short laboratory exposure is not sufficient for adaptation to occur.

Most previous models of word recognition seem to make the assumption that, before lexical access takes place, some form of normalisation process is applied to speech that eliminates indexical information, and provides the processing system with idealised versions of the speech in order to compare with the lexicon. This model attempts to explain how the normalisation process deals with indexical information, in particular accent-related variations. The presence in this model of an accent template that is applied to accented speech once a mismatch has occurred in the lexicon also lends further support to abstract entries models, as opposed to exemplar based models, of lexical representations. The normalisation process suggested by this model involves the development of accent templates in order to normalise the speech signal. This process therefore implies that the representations in the lexicon are abstract, idealised forms of words, and in order for the speech signal to find a match in the lexicon, it must be normalised into a similar abstract form. The presence of the accent templates means that accented exemplars are not stored in the lexicon, therefore suggesting an abstract entries model of lexical representations.

Overall, the findings of these studies have implications for our understanding of how accents affect speech comprehensibility. The presence of an accent in speech has been shown to cause an impairment compared with speech in our own accent. This study suggests that in order for our perceptual system to adapt to an accent, it requires a training signal to be sent, followed by the development of an accent template, in order to successfully process accented speech. It is this training signal (or lack of) that seems to be the cause of accent related impairment related to comprehensibility, and, if this is the case, it follows that our processing systems will never adapt sufficiently so that accented speech is processed as quickly as unaccented speech. In addition, adaptation to an accent, certainly related to comprehensibility, requires exposure to the accent over a period of time so that a training signal can be developed. This study has not been able to induce adaptation within the experiments, suggesting that the amount of exposure to an unfamiliar accent has not been sufficient, however adaptation to the familiar accents seems to have occurred prior to the experiments due to the presence of a familiarity effect (Adank and McQueen, 2009; Adank et al., 2007; Floccia et al., 2006; Maye et al., 2008).

Chapter 5

Literature review of developmental accent perception

So far this thesis has focused on how the presence of different regional and foreign accents impacts upon our speech processing systems as adults. The next section will look at the developmental origins of adult accent perception by examining infants' early perceptual abilities for accents during the first year of life, when infants are in the process of building up phonological representations for their maternal language.

Early phonological development

The primary task infants are facing when processing language is to learn the sound system of their native language. It is well established that between birth and the end of their first year, infants move from a universal phonetic sensitivity (e.g. Trehub 1976, Eimas, Siqueland, Jusczyk and Vigorito, 1971) to the acquisition of language-specific phonetic contrasts (e.g. Werker and Tees, 1984; Kuhl, Williams, Lacerdo, Stevens and Lindblom, 1992). Infants have also shown to be sensitive to, and learn to adapt to, talker variability in the speech signal (Jusczyk, Pisoni and Mullennix, 1992; Kuhl, 1979; Marean, Werner and Kuhl, 1992; Houston and Jusczyk, 2000; Singh, Morgan and White, 2004; Singh, 2008), and infants have also been shown to be able to discriminate between certain languages at an early age (Mehler, Jusczyk, Lambertz, Halsted, Bertoncini and Amiel-Tison, 1988; Mehler and Christophe, 1995; Nazzi et al., 2000).

To account for the changes observed between birth and the end of the first year, Velleman and Vihman (2005) reviewed three main models of phonological development; generative phonology, natural phonology and optimality theory. Generative phonology is a rule based account proposed by Chomsky and Halle (1968, cited by Velleman and Vihman, 2005) and these rules provide an explanation of how and why phonemes are produced in particular situations. However this model is limited in that it was suggested that the child's representations match adult representations, and that variations occur due to the child's underdeveloped physiology. However, as Velleman and Vihman point out, this assumption was questioned, and this model was criticised by sociolinguists and child phonologists for its inabilities to account for variability and because it did not constrain the rules when appropriate (Velleman and Vihman, 2005).

Natural phonology (Stampe, 1979, cited in Velleman and Vihman, 2005) is similar to generative phonology in that it also assumes that the child's representations match adult representations, however this model suggests that the child needs to overcome physiological limitations that are hindering perception and articulation that constrain the patterns of their own language. However, this model was criticised as merely labelling rather than explaining the process (Velleman and Vihman, 2005).

Optimality theory (Prince & Smolensky, 1993) suggests two forces at work; markedness, which is a preference for certain structures that are usually based upon how easy the child finds production and perception, and faithfulness, which is how close to the common representation produced words need to be in order to be understood. In contrast to other theories, these are not 'set in stone' rules but rather operate on a ranking system, where lower ranked constraints are only followed if they do not interfere with higher ranked constraints. This ranking system is used to explain variability in phonological development.

What Velleman and Vihman propose as an alternative to these three models is a pattern induction model. They claim that rather than any innate knowledge being available, the child has learning processes that are used to gather phonological information, analyse this information and then produce word forms. As this is done through sensor and motor capabilities that are available to all, this would explain variations because, in a sense, everyone has the tools, but are able to use them in their own way.

Vihman and Croft (2007) argue the case for what they call a 'radical' templatic phonology, which they describe as a template-based approach, where words structures are represented as language-specific phonotactic templates. They claim that these templates are a result of both early child productions (i.e. babbling) and experience with adult phonological patterns (i.e. adults talking to the child). The child is then able to use these templates to adapt words they hear to their own representations, and therefore extend their initial words forms used for first word production.

An influential model that attempts to explain how infants processes the speech input is PRIMIR (a developmental framework for Processing Rich Information from Multi-dimensional Interactive Representations, Werker and Curtin, 2005). The basic ideas behind this framework outline three dynamic filters that speech processing relies upon: the initial biases (e.g. newborn infants show a preference for infant directed speech, Cooper and Aslin, 1990), the development level of the child (e.g. change of sensitivity, within the first year, from both language-general and language specific phonetic differences amongst consonants, to only language-specific phonetic detail (Werker and Tees, 1984), and the requirements of the specific language task the child is facing (e.g. discrimination tasks require focusing on the differences between speech sounds, whereas segmentation tasks require focusing on phonetic similarities). These filters either enhance or diminish the raw physical features of the speech input, which allows the processing system to make full use of the rich information that is available in speech, so that information is then organised along many different dimensions. This simultaneous representation of multiple levels from the speech signal creates a number of emergent "planes", which the three filters need to work together in order to direct the speech processing system's attention to the correct plane (or planes). This framework is attractive because it provides an explanation for how children are able to organise information in such a way that they are able to utilise all information that is available to them, and the filters allow their recognition systems to be guided to the appropriate plane that is relevant to the task in hand.

Processing indexical information in childhood

Infants as young as two months old have been shown to be able to deal with talker variability to a certain extent (Jusczyk, Pisoni and Mullennix, 1992). In this study, infants were presented with examples of syllables (e.g. /bΛg/) spoken by various different speakers. Infants were either presented with a single speaker or multiple speakers, and were tested for a phonetic change using a high-amplitude sucking procedure. They found that the infants were able to detect a change from one syllable form to another (e.g. /bΛg/ to /dΛg/) even when multiple speakers were used. However, when a two minute delay was introduced between the end of habituation and the beginning of the test phase, infants were only able to detect the change in the single talker condition, and were not able to remember the speech sounds across multiple speakers. Attempts to reduce the variability that was evident in the multiple speakers' condition (such as using multiple talkers of the same gender) were not successful in aiding the infants' abilities to detect changes after a delay. However, the results showed that infants were able to detect a change in speaker, even after the delay period. What these results demonstrate is that infants at two months are sensitive to the variations that are present in the speech signal to which they are attending, in the sense that it can impair their ability to retrieve invariant phonetic information. This maybe because they have not yet learnt to attach any relevance to the information contained in speech in the way that adults do, and so variations are treated with equal importance by the infant.

In a study by Kuhl (1979), infants were shown to be able to recognise changes between spectrally dissimilar vowel categories produced by a single speaker, and then transfer that ability to items produced by other speakers. Six month old infants were trained to recognise a change from the vowel /a/ to the vowel /i/ by using a technique of head turn for visual reinforcement. In this method, infants are rewarded for a head turn by a visual reinforcer (a toy bear tapping a drum, or a monkey clapping cymbals). Initially, the infants were presented with a background stimulus sound of /a/ produced in a computer simulated male voice. When the background stimulus was changed to a /i/ sound, the infants were rewarded (by the activation of a toy that pounded a drum) if they performed a head turn during the presentation of the test stimulus. Once the infant had performed three consecutive head turns in a row, they were then presented with pitch variations, which encouraged the infants to ignore the acoustically prominent differences between the background and change stimulus while attending to the similar dimension, i.e. vowel colour. Once nine out of 10 correct head turns were recorded, the infants entered the talker variation stage, where the speaker producing the stimulus was varied between the original male voice and the new female and child voices. The results showed that the infants demonstrated rapid transfer of learning, so that the detection of change from the background stimulus to the test stimulus was transferred from those tokens produced by the male voice to those produced by the female and child voice. What this study demonstrates is that, by six months, infants are able to recognise invariant acoustic properties of vowel categories across different speakers and pitch variations.

Marean et al. (1992) aimed to replicate and extend the findings of Kuhl's study with two, three and six month olds using a different, observer based psychoacoustic method. This method involved an observer, who was deaf to the stimulus, using infants' behaviour to judge whether a vowel change had occurred or not (the vowel change was the same as used by Kuhl, 1979). The behaviours that could have been judged to have been a response included turning towards reinforcer, decreasing overall movement, tensing, or widening of the eyes. When the observer correctly identified a vowel change from the infants behaviour, a mechanical toy was activated, which acted as a reinforcer to the infant. They found that infants responded when there was a vowel change, however all age groups were shown to be able to ignore a change of speaker when there was no change of vowel as well, which seems to suggest that, even at an early age, infants are able to ignore some irrelevant indexical information in speech. These findings would seem to go against those by Jusczyk et al. (1992), where infants at two months were not able to recognise a vowel change in multiple speaker condition when there was a delay between habituation and test phases. However, the infants were able to recognise a change in the multiple speaker condition when there was no delay, which suggests infants are able to ignore indexical information when processing phonetic invariance at two months, however it is more stable when only a single speaker (rather than multiple speakers) is present.

With seven and a half month old infants, an age at which it was shown that infants can segment continuous speech to retrieve new words (Jusczyk and Aslin, 1995), Houston and Jusczyk (2000) used a version of the head turn preference procedure to show the effects of gender on speech perception. Infants were familiarised with examples of target words (e.g. cup and dog) produced by one speaker, and were then presented with four passages (made up of six sentences each), two passages contained examples of the target words, and two passages contained examples of new words (e.g. "the dog ran around the yard", "the mailman called to the big dog", etc.). The isolated words and passages were recorded by both male and female speakers, and infants were presented with either two male or two female speakers, or by one male and one female speaker. Looking times were recorded to the passages in the test phase, and were analysed to see whether infants attended longer to passages containing the target words or not. Results showed that infants were able to recognise familiarised target words in continuous speech across different speakers only when the speakers were of the same gender, and were not able to generalise across genders until 10.5 months.

Affect has also been shown to effect perception. Singh et al. (2004) used a similar method to Houston and Jusczyk (2000), where infants were familiarised with examples of words and then tested as to whether they would recognise these target words in passages containing them (compared with passages that did not contain these target words). However, in this study the words and passages were recorded using different affective states (e.g. happy or neutral). Singh et al report that happiness in speech can be measured in terms of increases in high frequency energy in the F_0 spectrum, mean F_0 and F_0 range. Infants were familiarised with two words, one spoken with a happy affect and the other spoken in a neutral affect. The infants were then presented with passages containing or not the familiarised words, and these were also presented in happy or neutral affect. They found that, at seven and a half months, infants only displayed recognition for familiarised words that matched across affect (happy affect words presented in happy affect passages, neutral affect words presented in neutral affect passages). By 10.5 months, infants were demonstrating more mature recognition abilities, recognising familiarised words even when the affect of both words and passages did not match. In a subsequent study, Singh (2008) further investigated the impact of affect and developed the idea of low and high variability in spoken word recognition. By introducing other forms of affect (sad, angry and fearful, as well as happy and neutral) into a method similar to Singh et al (2004), she was able to demonstrate that, when exposed to a high level of variability, infants' word recognition abilities were increased at seven and a half months, while also claiming that low variability degraded word recognition, similar to the earlier findings. In this study, infants were presented with two target words, one presented in multiple forms (i.e. happy, neutral, sad, angry and fearful), and the other presented in one affect. They found that, at seven and a half months, the infants were not only able to recognise the multiple affect target word in continuous speech, but this also generalised to the other target word as well. It seems that this exposure to greater variability was able to prompt more mature segmentation abilities earlier. However, they also found that infants seemed to place more importance on surface similarities than phonetic differences. When presented with examples that matched on affect but differed phonologically (such as "bike" and "dike"), the infants treated these mismatched words as a match if the affect was the same. What this study suggests is that infants rely on all forms of variability within speech, and that the presence, or lack of, a range of variability encountered by infants has implications for how they perceive and process these variations.

The results of these studies suggests that the greater the amount of variability that infants are exposed to, the better infants become at encoding more generalisable representations of words, and effectively ignoring, or filtering out, irrelevant indexical information. When infants are exposed to a low amount of variation in speech, infants are worse at ignoring indexical information. It is not till later in development (around 10.5 months) that infants are able to adjust their perceptual abilities to filter out irrelevant information, such as gender and affect of the speaker, regardless of the amount of variation that they are being exposed to.

In summary, it would appear that the ability to extract invariant phonetic information across indexical variation such as the speaker's voice develops during the first year of life. Through exposure to the maternal language and perhaps maturation, infants learn to normalise the incoming speech signal from "irrelevant" information. Another contentious issue relates to how infants perceive accent-related information, as this requires them to deal with variation across a wide range of acoustic and linguistic dimensions, that is, prosodic and segmental changes. Given this amount of variability, is it justified to study perception of accents as whole, rather than isolate each component of an accent and examine how children perceive each of them? One way to answer this question is to observe that in adults, there seems to be a psychological reality to the concept of accents and dialects. That is, we are able to broadly categorise and identify accents, as a whole, successfully to a certain degree (Clopper and Pisoni, 2004 for example). Therefore, at this point, even though accent related information can refer to a wide range of variability, it seems justified to look at accent perception in infants in a broad way, rather than attempting to identify how the different types of information generated by the presence of accents affect perception. Further research will certainly help us refine what kind of information infants are paying attention to in accents, but at the starting point of this thesis, accents are referred to as a general linguistic and acoustic object, and specific types of information will not be identified or extracted from them.

Early Language perception

The studies described above demonstrate infants' abilities to deal with some forms of indexical variations, namely talker identity, gender or emotions. Thus far none of the studies have specifically addressed accent perception, but one area of particular relevance to this issue relates to infants' abilities to discriminate and categorise languages. Until a certain point, an infant at the onset of language acquisition facing two languages can be compared with a child facing two varieties of her maternal language, for example British English and New Zealand English, as both entail phonetic, phonological and prosodic differences. During the first months of life, infants are not processing syntactic, lexical or pragmatic information that would allow them to distinguish the languages. What we know about language discrimination in infancy might help us understand or predict what would happen regarding accent discrimination.

Mehler et al. (1988) investigated language discrimination in four day old French infants, and two month old American infants. For the four day old infants, they presented them with utterances spoken in two languages by the same bilingual speaker, and they measured sucking rates on a pacifier to look for evidence of discrimination. They used two bilingual speakers, one who was French/Russian bilingual and one who was American English/Italian bilingual, and utterances were selected by recording the speakers talking about events in their life (in both languages), and then extracting utterances from these recordings (matched as far as possible in each language in length). They used both four day old infants from monolingual French homes, and infants whose primary home language was not

French (a variety of different language backgrounds was present). They found that infants were only able to discriminate between languages when their own language was present (French monolinguals able to discriminate between French/Russian but not English/Italian), and the infants with a different primary language to French (but living in France) were not able to discriminate French/Russian. The American two month olds were tested using a "looking while listening" method, where listening times were recorded based on whether the infant was fixated on a picture, presented on a screen, while the stimuli was playing (the rationale with this technique is that if the infant is fixated on the picture she is thought to be listening to the stimuli). They found that, at two months, the American infants were able to discriminate between American/Italian (their own language present) but not between French/Russian. The results of this study indicated that infants' ability to discriminate between different languages is dependent on their familiarity with one of the languages. However, a reanalysis of these data in Mehler and Christophe (1995) revealed that French born newborns did actually discriminate Italian from English. So the idea was that at birth, irrespective of their maternal language, newborns can discriminate any pair of languages.

However, building upon these studies, Nazzi et al. (2000) demonstrated that the picture was slightly more complicated. They proposed that five month old infants are able to discriminate between different languages depending on the rhythmic class of the languages and their familiarity with the languages (rhythmic class refers to the sound patterns of a language, i.e. syllable based such as French and Italian, stress based such as English and German, mora based such as Japanese). They used a modified version of the head turn preference procedure coupled with a habituation technique in which American English learning infants are familiarised with one language, and then presented with both the habituated language and a new language. They analysed looking times for differences between the two languages (longer looking towards the source of one of the languages was taken as evidence for discrimination). They were able to show that infants could discriminate between two languages from different rhythmic classes (e.g. British English v. Japanese; Italian v. Japanese) and also between two languages from the same rhythmic class only when one of the languages was their own or a dialectal variant of their own language (e.g. British English from Dutch; American English from British English). They could not discriminate between two unfamiliar languages either within their own native rhythmic class (e.g. Dutch v. German) or within a non-native class (e.g. Italian v. Spanish). The authors argue that it is most likely that infants are using prosodic information in order to distinguish languages from within the same rhythmic class (i.e. British English from Dutch, and American English from British English). For example, their analysis of the American English and British English stimuli suggests that British English had longer durations for stressed syllables and shorter durations for unstressed syllables than American English. This shows that by five months, infants have refined their representation of rhythmic classes that they displayed at birth, so that they can now perform fine-grained discrimination within the rhythmic class their native language belongs to, and only when their language is present.

What is interesting about these findings is that by five months infants seem to have learnt to distinguish their own language from others, but do not necessarily discriminate between two languages that are both different (and unfamiliar) to their own native tongue. In a paper by Kuhl et al. (1992), it is suggested that by six months experience of the native language alters the phonetic perception of infants so that they are more attuned to the speech vocalic sounds and variability within their own language compared with foreign languages. They presented infants with examples of vowels that were typical of their own language and vowels that were typical in a different language (infants were American and Swedish, and the vowels were typical American English and Swedish vowels). They computer-synthesised variations of these vowels and presented them to the infants. They used a head turn method where, when there was a change in the vowel sound, if the infant turned toward the sound they were rewarded by the activation of a toy that pounded a drum (see also Kuhl, 1979, that looked at speaker and pitch discrimination in vowels, using the same technique.). They found that infants judged variations of the vowel to be the same as the prototype in their own language only, performing at chance for the other language. These results show that infants have learnt something about variability in their own language by six months in that they are able to generalise across acoustic variations and recognise the prototype, but they cannot do this in a language different to their own. This suggests that the reason that infants are able to discriminate their own language from others, but not two unfamiliar languages is because they have not yet learnt enough about variability in other languages, as they have with their own language, that would allow them to discriminate foreign languages from each other.

Another demonstration of children's ability to discriminate between different languages was shown in a study by Kinzler, Dupoux and Spelke (2007), showing that American English learning children can use languages to guide behaviour, at several different stages of development (six months, 10 months, and five years). They conducted a series of experiments at several points in development to investigate how the presence of different languages can affect behaviours in infants and young children. First they presented six month old infants with films of two women speaking, one who spoke in their native language (English) and the other who spoke in a foreign language (Spanish). After this familiarisation phase (where both speakers were presented for equal time to the infants), both speakers were presented side by side in the test phase, only this time they did not speak, and they found that the infants looked reliably longer to the speaker who had previously spoke to them in English. They then tested 10 month old infants from America and France, who were presented with films of one English speaker and one French speaker, who spoke alternately in their native language. The speakers then appeared side by side and silent, and both offered an identical toy at the same time, and then the toys appeared within reach of the infant, creating the illusion that the toy had come from the screen. They found that the

American infants reached for the toy from the English speaker, while the French infants reached for the toy from the French speaker, showing a preference for the speaker who had previously spoke in their native language. A further experiment was conducted with five year old monolingual English speaking children, where they were presented with photographs of two unfamiliar children while they heard them speaking in either English or French. The children were then asked to decide who they would rather have as a friend. They found that the children chose a child paired with English speech rather than the child paired with French speech. This study demonstrates that, at different stages in development, young infants and children are able to perceive differences between different languages and to use this ability in order to guide social behaviours. In addition to these findings related to language perception, they also demonstrated accent perception effects, which will be discussed later.

Early Accent perception

An interesting finding in the Nazzi et al. (2000) paper is that American five month olds were able to discriminate between their own dialect and a variation of that dialect, as demonstrated by longer looking times to the novel accent over the familiarised accent in the habituation phase. In this case the comparison was between American accented and British accented English. It would appear that at this age infants have either learnt something about their own native dialect and so are able to discriminate their dialect from other variations, or that they have acquired general discrimination abilities that allow them to discriminate between any dialect variations in their native language, including American and British accented English if they learn English.

A study by Kitamura, Panneton, Notley and Best (2006a) also investigated this effect using both Australian and American infants. They used a preference procedure where six month old infants were presented with 12 trials, six in Australian accented English and six in American accented English, with dialect presentation alternating across trials. Each trial was made up of five utterances which were matched for mean F0, pitch, range, durations and level of positive vocal affect ("Look at the orange bears", "Today is going to be so nice", "We came in our car, didn't we?", "Let's look for a game", "Where's your toy?"). Half of the infants heard American-accented speech first while the other half heard Australian-accented speech first. They reported that at six months, American infants showed a preference for Australian accented speech, especially when they were presented with their own dialect first, but Australian infants did not demonstrate any preference. In a subsequent experiment they used a habituation procedure with Australian infants, where one of the dialects was presented to the infant on repeated trials until there was an average 50% decrement in looking time over two trials compared with the first two trials, following which the infants were presented with two no change control trials of the same dialect followed by two test trials of the novel accent, to test for discrimination between the two varieties of English. Looking times were compared between the control and novel dialects, and they found no evidence of discrimination at six months. The authors claimed that this was because Australian infants were more familiar to American accented speech (through television) and so were able to filter out irrelevant phonetic information from American English, earlier than American infants with Australian English.

The age difference above between Australian and American infants' discrimination for Australian versus American accent is intriguing. The authors suggested that repeated exposure to the maternal language led to this decline in discrimination abilities, with Australian infants having greater exposure, earlier, to American accented English through the greater availability of American TV shows in Australia (Kitamura et al, 2006a) To confirm this hypothesis, they used the preference procedure outlined above with three month old Australian infants, and reported that, at three months, Australian infants showed a preference for Australian accented speech. The authors suggest that the greater the exposure to non native dialects that young infants experience, the less likely they are to discriminate it from their own accent. The difference between American and Australian infants in this study does suggest that perhaps Australian infants are experiencing a greater amount of variability in the speech signals that are available to them compared with American infants, which could explain why they show a preference at three months but not at six months.

A study by Diehl, Varga, Panneton, Burnham and Kitamura (2006) looked at American infants' preference for native versus non native language sounds, using a serial preference procedure and natural recordings of American and Australian accented females. They found that, at six months, American infants showed longer looking times to the unfamiliar dialect, however at eight months, this effect was not significant any more. This suggests a similar pattern as that demonstrated by Kitamura et al (2006a), although at an earlier age, for Australian infants. Whatever the reason for this age difference, perhaps the reason for this apparent decline is, as infants between six and eight months are entering lexical acquisition phase, they start to focus on phonological similarities rather than surface discrepancies. In other words, between six and eight months, they might still perceive differences amongst accents, but in discrimination tasks, they would pay more attention to the convergences between accents rather than to the divergences.

This is further supported by a study by Phan and Houston (2006), who found a decline in the ability to discriminate dialect-related cues in isolated words between seven and 24 months. Infants were seated on their caregivers lap in front of a TV monitor. Each trial consisted of a visual display of a checkerboard pattern and an auditory stimulus. Infants were habituated with repetitions of the word "pine" produced in their home north midland American accent or in an unfamiliar southern American accent, and then, in the test phase, were presented with the same word in both the north midland and southern American accents. Looking times were recorded. Results showed that only the seven month olds could discriminate the two pronunciations of "pine", whereas the three older groups (11, 18 and 24 months) showed no signs of discrimination. This suggested that again, after seven months of age, infants entering the lexical acquisition phase have started normalizing surface variability in speech inputs, so that they can represent incoming words as abstract phonological representations with no need for irrelevant dialect variations.

Further evidence for a loss of sensitivity to accent information was shown by Floccia et al. (2009). They investigated regional and foreign accent categorisation in five and seven year old British children by presenting the children with an imaginary scenario where all sentences stored on a laptop had been mixed up, and that the experimenter needed the child's help to sort it out. The children were told that there would hear a series of spoken sentences that were either from Plymouth (where the child was from), or were aliens from another planet, who therefore spoke differently. The "alien" voices were in fact speakers who had either a regional (Irish) accent, or a foreign (French) accent (the children were randomly assigned into two conditions; the Irish condition, where the "aliens" were Irish speakers, and the French condition, where the "aliens" were French speakers). The children were instructed to respond by pushing the appropriate response button, blue for someone from Plymouth and red for an alien. They found that at five years, the children performed poorly in this task, and were not sensitive to the different accents used (they were able to perform a control gender categorisation task where the speakers were either male or female, which suggests they understood the task and were sensitive to other indexical information). However, at seven years, the children were able to perform this task with both regional and foreign accents, and were also significantly better at recognising the foreign accent over the regional accent (see also Girard et al., 2008, for similar findings with French children). These results suggest two things about children's perceptual ability for accents. Firstly, that there appears to be a U shaped curve in the development of perception for accents, where at five months infants are able to discriminate accents (Nazzi et al., 2000) but this ability appears to decline by seven months, and perhaps persists in this decline until between five and seven years of age. Secondly, there appears to be a difference between the perception of regional and foreign accents, as shown by the seven year olds better performance on foreign accents. This could be due to different perceptual systems relating to regional and foreign accents, or it could be due to a greater familiarity for regional over foreign accents acquired in childhood.

However, in contrast to these studies suggesting a decline in discrimination abilities, Kinzler et al. (2009) demonstrated infants at six months and children at five years could use foreign accents to guide behaviours. Using the preferential looking method mentioned previously (see language perception section), American and French six month olds were presented with two speakers, one speaking in their native accent and one speaking with a foreign accent. The infants were familiarised by hearing both speakers and were then presented with a silent test trial, where both speakers were presented again, but silent. They found that the infants preferred the speaker with the native accent over the foreign accent, even though they looked equally to both speakers during familiarisation. For the five year olds, American children were presented with photos of children's faces paired with either an American accented or French accented voice (for detailed method, see language perception section, above), and results showed that the children chose the child paired with their native, American, accent to be their friend. What this study demonstrates is that infants and children are able to use accent related information to guide social behaviours. This would suggest that, rather than a decline in discrimination abilities, in fact it is the task that perhaps dictates whether accent related information is utilised or not.

In summary, during the first year of life, infants seem to be learning about variability in speech related to languages and accents. Regarding languages, it seems that infants' ability to discriminate pairs of languages is dictated by both an innate bias towards perceiving differences between rhythmic classes, and their growing exposure to their native language (Mehler et al., 1988, 1995; Nazzi et al., 2000; Kuhl et al., 1992). By five months, infants can discriminate two languages from different rhythmic classes, regardless of whether their own language is present (Nazzi et al., 2000). They are also able to discriminate between languages within a rhythmic class, as long as their own language is present (Nazzi et al., 2000). Children's ability to discriminate languages persists throughout childhood, and they have been shown to use language differences to guide behaviours at six months, 10 months and five years (Kinzler et al., 2007). Regarding accents, American infants between five and six months seem to be able to discriminate (or display preference) between their own and another accent (Nazzi et al., 2000; Kitamura et al., 2006a; Diehl et al., 2006; Kinzler et al., 2007), however, Australian infants at six months do not show preference for their own accent over an American accent, but are able to do so at three months (Kitamura et al., 2006a). There also seems to be evidence that American infants from eight months onwards also cease to display discrimination for accents (Diehl et al., 2006; Phan and Houston., 2006), although children at five years have been shown to be able to use foreign accent related information to guide social behaviours (Kinzler et al., 2007). The differences in ages between American and Australian infants suggest that perhaps greater exposure to accent variation affects the likelihood of infants discriminating based on accents.

Accents and Word Segmentation

Another relevant area which has started attracting attention recently is the study of word segmentation from continuous speech in infants from eight months onwards, and especially the role of variability in segmentation tasks. These studies are follow-ups of a seminal report by Jusczyk and Aslin (1995) showing that seven and a half month old American infants can retrieve a new word form from passages containing or not this word. For example, infants are habituated with the two items feet and cup, and then presented with passages containing feet and cup, but also bike and dog which have not been presented before (this would be the word-passage version of this paradigm). By seven and a half months infants would listen longer to passages containing the previously habituated words. Using this technique, and of direct interest for our topic, a set of studies examined how Canadian-French and Parisian-French learning infants develop word segmentation abilities skills (Polka, Proulx, Mersad, Iakimova, Sundara and Nazzi, 2008; Nazzi, Mersad, Iakimova, Polka and Sundara, 2008; see also Polka and Sundara, 2003; Nazzi, Iakimova, Bertoncini, Fredonie and Alcantara, 2006), and revealed a slight advantage for Canadian-French learning infants in the ability to retrieve disyllabic words at eight months. Specifically, on the contrary to Canadian-French learning children, Parisian-French learning eight month old infants failed to recognise a target word from within passages containing this word, in a word-passage paradigm. However, they succeeded in the task if the passages were presented first as habituation, and then followed by the isolated words (passage-word paradigm). As suggested by Nazzi (submitted), this could be due to the fact that Parisian infants might need more time to process the passages than Canadian children, a consequence arising from the fact that Canadian French dialect is characterised by larger intonation variations than Parisian French (Ménard, Ouellon and Dolbec, 1999), which would provide Canadian French learning infants with more cues for word segmentation. These studies suggest that within-language differences might affect children's developmental course of language learning.

Similarly, Schmale and Seidl (2009) carried out a series of word segmentation studies in American infants contrasting American English accent and a foreign Spanish accent, in nine to 13 month old infants. Results showed that by nine months of age, infants failed to recognise the habituated words if two different foreign speakers were used to produce the habituation and test stimuli, whereas 13 month olds could do the task, showing greater abilities to abstract phonological information from variable speech. These results were collected with foreign accented speech, and so it would appear that infants have not learnt enough about foreign accents in speech at nine months in order to be able to normalise the speech signal to the extent that they are able to recognise a familiar word if it varies enough from their internal representation through the presence of a foreign accent. It is also possible that, between nine and 13 months, rather than having learnt anything about foreign accents at 13 months, infants have had further exposure to languages, and in particular more exposure to the many different forms of variability that are prevalent in speech. This exposure may provide infants with help in dealing with foreign accent variability that they would not have at nine months. They may also have developed more fine-grained procedures in order to access phonetic segments in speech, resulting in the improvement seen at 13 months. In summary, what these findings suggest is that children begin with very sensitive perceptual abilities to distinguish between different dialects, as shown by their ability to discriminate between regional varieties of their own language at five months of age (Nazzi et al., 2000; Kitamura et al., 2006a), however this ability appears to decline as the infant develops, after six months (Kitamura et al., 2006a; Phan and Houston, 2006; Floccia et al., 2009a; Girard et al., 2008). However, this decline does not seem to be permanent, and by seven years children seem to be able to discriminate accents, but not at five years (Floccia et al., 2009a; Girard et al., 2006), suggesting possibly a U shaped curve in development. There does appear to be discrepancies in the age when the initial decline occurs, which could be due to differences in the amount of exposure to different accents in different cultural backgrounds (age differences between American and Australian infants, Kitamura et al., 2006a). There also appears to be differences in discrimination abilities for regional and foreign accents at seven years, when discrimination abilities seem to resurface (Floccia et al., 2009a; Girard et al., 2006). This could be related to familiarity with the accents, or it could be that different processing mechanisms are utilised for regional and foreign accents. What is also not clear from the literature is what infants know about their own and regional variations of their own dialect. There seems to be some evidence that very young infants are able to discriminate between their own dialect and other variations (i.e. American versus British English, American versus Australian English). What is not known is whether infants have learnt something specific about their home dialect which allows them to discriminate their own from other dialects, or whether they have a more general discrimination ability for varieties in their native language.

However, a closer look at evidence underpinning the postulate of a U shaped curve in development could negate this very hypothesis. A closer inspection of the Australian and American infant studies reveals at least three methodological uncertainties. Firstly, the results obtained by Diehl et al. (2006) with American infants is not clear cut, as they report finding a significant preference for Australian English as compared with American English in both groups, six and eight month old infants, whereas Kitamura, Panneton, Diehl and Notley (2006b) refer to these findings as being non significant at eight months.

Second, and most importantly, the stimuli which have been used in this series of studies (Kitamura et al., 2006a, 2006b and Diehl et al., 2006, experiment 3) consist of the following short IDS sentences: 'We came in our car, didn't we?', 'Where's your toy?', 'Let's look for a game,' 'Look at the orange bears', and 'Today is going to be so nice.' Each sentence is produced by 4 speakers for each accent (Australian and American English) and then arranged as a string of five sentences (with at least one token from each speaker) in a particular accent. So for example, as far as I understand it, a trial will consist of five repetitions of the sentence "Where's your toy?" uttered by four speakers with an Australian accent. These sentences are short and made of common words and structures in infant-directed vocabulary. Presumably, these sentences might sound familiar to infants, at an age at which they have been found to store their first lexical representations (Tincoff and Jusczyk, 1996). In addition, the presentation of multiple tokens of one of these sentences can help infants build up a representation of the whole utterance or parts of it across irrelevant surface variations, an ability which has been reported to grow with repeated exposure to the maternal language (Singh, 2008). Therefore it is possible that the design of the American and Australian preference studies perhaps engaged the children in a task which tests for their ability to normalise speech across dialect variations, rather than for their preference for one dialect over the other.

Finally, all experiments but one in the studies reported by these researchers have used a preference procedure (the exception being a habituation task used in Experiment 2 in Kitamura et al., 2006a, also reported as Experiment 2 in Kitamura et al., 2006b). This was done because the authors had predicted some familiarity effect for the home accent. However, a failure in a preference task does not necessarily mean that a failure in a discrimination task would be observed, and perhaps the use of discrimination procedures would bring more sensitive results.

Therefore, the starting point for this infant research (Experiment 8) is to investigate whether British English learning infants demonstrate the ability to discriminate between their home dialect and another, unfamiliar regional dialect, as a replication of the Nazzi et al. (2000) study. The next stage (Experiment 9) will be to investigate whether the infants are able to discriminate between two unfamiliar regional variations of their own dialect. Available evidence suggests that after six months, infants' discrimination abilities for their native language dialects seem to decrease, whereas at five months, American English learning infants are able to discriminate American and British English (Nazzi et al., 2000). Therefore, five months seems to be the appropriate age to explore the origins of dialects discrimination abilities: dialect-specific or general. Once infants' discrimination abilities at five months have been understood, the possibility of a similar decline in discrimination abilities at seven months will be examined (Experiments 10 and 11), as shown by Kitamura et al. (2006a).

From the review of the literature, the following hypotheses can be made. The first hypothesis concerns infants' early abilities to discriminate speech based on accents. If infants have been learning specifically about their own accent, it is expected that infants at five months will be able to discriminate their own accent from another, unfamiliar accent, but they will not be able to discriminate between two unfamiliar accents. However, if infants by five months are focused on the phonetic differences between specific accents, but have not yet learnt specifically about their own accent, it is expected that the infants at 5 months will be able to discriminate between accents, regardless of their familiarity with the accents. This will be investigated in Experiments 8 and 9.

The second hypothesis concerns the reported decline in infants' discrimination abilities (Kitamura et al, 2006a). If infants' sensitivities to accents in speech have declined, perhaps due to a shift in focus from phonetic detail towards understanding word meaning, it is expected that infants will not be able to discriminate their own accent from an unfamiliar accent at seven months. However, if infants are still attuned to the phonetic details of speech, it is expected that infants will still discriminate an unfamiliar accent from their own. This will be investigated in Experiments 10 and 11.

Chapter 6

Accent discrimination in infancy

In this chapter, four experiments testing five and seven month olds' discrimination of pairs of dialects or accents will be presented, using a head turning preference paradigm. The aim is to examine what infants have learned about their native language that can allow them to distinguish between two dialects, to lay down the foundations of accent normalisation abilities as observed later in life.

Experiment 8: Early native accent discrimination at five months

In this experiment BE-learning five month-olds from the West Country will be tested to ascertain whether they are capable of discriminating between their own home dialect and an unfamiliar Welsh dialect of English. The procedure will be an adaptation of the Headturn Preference Procedure to provide a discrimination measure (see Bosch, 1998), as used by Nazzi et al. (2000).

Stimuli

Stimuli were the exact replication of those used in the study of Nazzi et al. (2000). Eight passages consisting of five unrelated sentences (see appendix B) were recorded by four female speakers with a Plymouth accent (aged 20, 22, 29, 30; all speakers resident in Plymouth throughout their life) and four female speakers with an accent from South Wales (aged 19, 20, 21, 24; all speakers resident in South Wales until at least 18 years of age, for details of all speakers used in Experiments 8 to 13, see appendix D). Each of the passages was recorded by one speaker of each accent, with each speaker recording two passages each. In order to make the passages interesting to children the speakers were instructed to read them in child oriented speech. Passages were recorded using a digital dictaphone and microphone, using 16 bit, 44100Hz sampling rate. The average duration for the passages was 20.23 seconds (Plymouth passages – 20.57; Welsh passages – 19.89).

Dialect characteristics

Dialects can be characterised at the segmental and the supra-segmental level. For the South Wales area a description of the intonation system of this dialect is provided by Walters (2001) who analysed samples produced in the Rhondda Valley, an area of South-East Wales. The Welsh dialect of English has borrowed many prosodic features from the Welsh language, which resulted in a shortening of stressed vowels and lengthening of succeeding consonants, a pitch-rise from the stressed syllable and an increase in phonetic strength of the post-tonic syllables, and finally a shift of word stress from initial to penultimate or ultimate syllable in polysyllabic words. Intonational phrases are of two main kinds: a sequence of rising contours that can end with an ultimately rising nuclear contour, or with an ultimately falling contour. All these features contribute to the popular feeling that Welsh English is a "sing-song" dialect (Wells, 1982, p. 392). At the segmental level, according to Hughes and Trudgill (1988) Welsh English is characterised by its non-rhoticity (no post-vocalic "r"), the distribution of /æ/ and /ɑ:/ which follows that found in the North of England, and the vowel /ɛ:/ in "bird" being rounded to approach /ø:/. In addition, the phoneme /l/ is never dark, that is, it is not velarised after a vowel as in English Received Pronunciation.

The West Country dialect of English belongs to the family of Southern English dialects (Wells, 1982), and thus has intonation patterns that do not depart significantly from that of the Received Pronunciation English. Bollinger (1989) notices in RP English a high proportion of high initial pitches, leading to more frequent and more extended falls than in Network Standard American English (p. 29). There is also a higher proportion of terminal rises in BE than in AE. However, in the West Country short vowels tend to be longer than in other South of England accents, especially in monosyllabic words in phrase-final or prominent position (Wells, 1982, p. 345), resulting in the popular feeling that West Country dialect is slow. At the segmental level, it is distinct from RP English in its rhoticity, the loss of the /ae/ and /a:/ distinction (Hughes andTrudgill, 1988), and by the fact that words like boat and gate have usually retained their monophthong pronunciation (Wells, 1982).

Listening to the recordings of the speakers a trained phonetician reported that the accents were mostly recognisable by their segmental features rather than by their prosodic patterns as the speakers read the passages rather than spoke spontaneously. In addition, all the stimuli used in this study (Plymouth, Welsh, Scottish and French speakers; Scottish speakers were used in Experiment 9, and French speakers in Experiment 11) were presented to eight naive adult listeners (all brought up in the South of England, but resident in Plymouth for at least the previous three years; mean age: 39.7 years, including four females) in a forced choice accent identification task. Each participant was presented with 32 randomly ordered passages (two passages for each of the four speakers within each accent) and asked to make a choice (Plymouth, Welsh, Scottish or French) and confidence rating (1 - no confidence, to 4 - very high confidence) on the accent. Regarding the Plymouth and Welsh English results, participants identified correctly the Plymouth passages in 98.4% (from 87.5% to 100%) of cases with a mean confidence of 3.13. The only incorrect response was due to one participant identifying one passage as being Welsh-accented with a confidence of 1. The Welsh English passages were correctly identified in 85.9% (from 75% to 100%) of cases with a mean confidence of 3.11. When identified incorrectly, Welsh accented sentences were all identified as being from Plymouth (9 responses out of 64), with a confidence of 2.8. Although listeners did not perform at a ceiling level (see Clopper and Pisoni, 2004, for similar observations with American listeners), the high degree of accuracy in accent identification, coupled with the trained phonetician report, suggests that the stimuli were representative of the target accents.

Participants

Twenty healthy monolingual infants (11 males and 9 females) with a mean age of 5.37 months (range 4.49 – 6.07) participated in this study, all of whom were raised in the

West Country region of England from birth. Apart from three of the infants whose parent(s) originated from the North of England, both of the parents of the children also originated from either the West Country or the South of England. In all cases parents reported that the children had no particular exposure to Welsh accented speakers. Post-hoc analyses showed that there was no significant effect of the parents' origins on the infant's discrimination score, $F(1,16) < 1$. The methods and aims of the experiment were fully explained to the parents of the children, who completed an ethical consent form before testing began. Seven additional infants were excluded from the study due to crying or failure to pay attention to the lights or sounds used in the experiment (4), or because at least one of the parents originated from outside England (3). None of the infants were more than six weeks premature, nor did they have any diagnosed developmental problems. These last two criteria will be used in all subsequent experiments, and will not be repeated again.

Procedure

Accent discrimination responses were collected using an adaptation of the Headturn Preference Procedure (HPP: see also Nazzi et al., 2000). During the experiment infants were seated on their caregivers lap in the centre of the test booth. At the beginning of each trial a flashing green light was presented at the centre-front of the booth to focus the infant's attention to the middle of the test area. This green light was then turned off and replaced with a flashing red light, which could either be to the left or right hand-side of the booth. The location of the red light was chosen on a pseudo-random basis, such that the light could not appear on the same side for more than two consecutive trials. Once the infant turned to look at the flashing light, one of the stimuli passages was played from a speaker next to the light (the red light continued flashing during the presentation of the passage). If the passage ended, or the infant looked away from the light for more than two seconds then all lights and sounds were terminated and after another few seconds a new trial would begin. Control of lights, speech stimuli, and the monitoring of the infant's looking times were all synchronised and remotely controlled by the experimenter using a bespoke computer program. Both the experimenter and the infant's caregiver wore headphones playing music during the experiment so that neither was aware of the accent of the speech stimuli presented to the infant.

Before the test phase each infant was habituated to a particular accent using four-sentence passages from two of the speakers of that accent. During habituation the infant was required to accumulate a total of 20 seconds of looking time to each of the passages. Half of the infants were habituated to Plymouth accented passages, and the other half were habituated to Welsh accented passages. Once this time-locked habituation was complete, the test phase began, with a randomly ordered presentation of four Plymouth and four Welsh dialect passages (spoken by the four speakers not used during habituation). During each of the test-phase passages the infant's looking times were recorded by the experimenter, with average looking times for each accent calculated by the computer control program.

Results

Figure 32 shows the mean looking times for the West Country and Welsh dialect passages, with an average looking time of 8.58 seconds for the habituated accent, and 6.82 seconds for the non-habituated accent. Of the twenty infants tested sixteen had longer looking times for the habituated accent than the new accent. Comparing dialects, we found that seven out of ten infants habituated to the Plymouth speech had longer looking times to that accent. For the Welsh dialect this rose to nine out of ten.

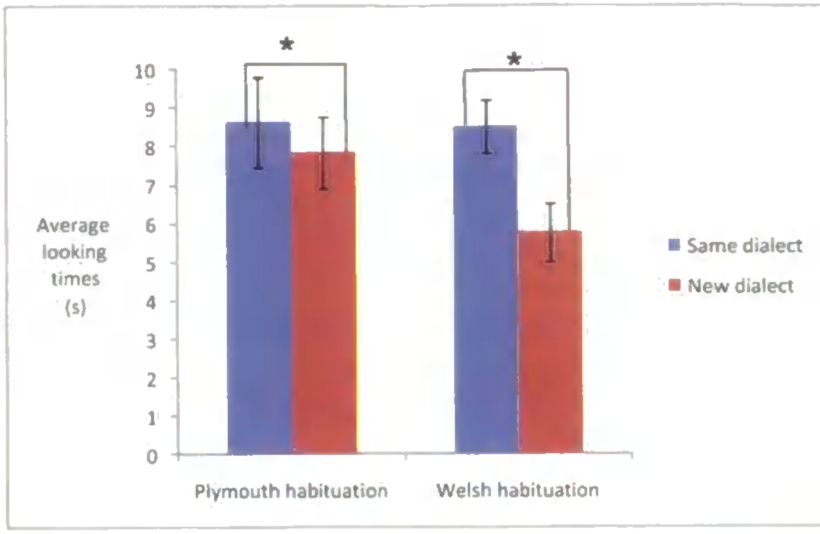

Figure 32: Mean looking times to the habituated and new accent, broken down between conditions.

A 2 X 2 repeated measures ANOVA was carried out on the looking times, with a within-participants variable of dialect status (same vs. new dialect) and a between-participants variable of dialect group, that is, the dialect children were habituated to (Plymouth vs. Welsh English). This showed a significant main effect of dialect status, $F(1,18) = 6.7$, $p = .019$, $\eta^2 = .271$, with significantly longer looking times for the habituated dialect than the non-habituated dialect. There was no significant effect of dialect group, $F(1, 18) = 1.02$, $p = .33$, $\eta^2 = .05$, and no interaction between dialect status and accent group, $F(1, 18) = 2.05$, $p = .17$, $\eta^2 = .1$.

Discussion of Experiment 8

The results of Experiment 8 demonstrate that five month old infants from the South West of England are able to discriminate between their own regional variation of British English and that of another region. These findings are consistent with previous findings from a range of language backgrounds (Nazzi et al., 2000; Kitamura et al., 2006a; Diehl et al., 2006).

Interestingly, while the discrimination ability is consistent with previous studies, the infants in this study seem to show a preference for habituated over the non-habituated dialect, which is the opposite of the effect reported by Nazzi et al. (2000), who found that American five month olds looked longer to the non-habituated dialect (American English vs. British English; AE vs. BE). Observation of novelty versus familiarity effect in visual preference-related paradigms is rather common in the literature, and probably the most famous example is that of Jusczyk and Aslin (1995) and Saffran, Aslin and Newport (1996), who tested recognition of words in fluent speech at respectively seven and a half months and eight months. Whereas the former reported a familiarity effect, the latter observed a novelty effect. Houston-Price and Nakai (2004), reviewing the novelty versus familiarity effects in procedures similar to the one used in this experiment (a familiarisation adaptation of the HPP), mention that at least three factors can influence the observation of a novelty versus a familiarity effect: the number and length of familiarisation trials, the age of the children and the complexity or salience of the stimuli (see also Roder, Bushnell and Sasseville, 2000 in the visual domain). Given that children's ages, number of familiarisation trials and choice of the sentences are very similar between our study and that by Nazzi et al., the only possible explanation could be related to a difference in stimulus salience. Contrary to that of Nazzi et al., who used Adult Directed Speech (ADS) stimuli, my stimuli used infant-directed speech (IDS), a very attractive speech mode for young infants (Fernald, 1985), which could have held infant's attention to the habituated dialect for longer. According to Schöner and Thelen (2006), "the more arousing or interesting or complex the habituating stimulus, the more infants look at it and the longer it takes to reach a habituation criterion." (p. 277). This is reflected in Thompson and Spencer's (1966) model of habituation, where there is an inverse relationship between the general level of activation or arousal elicited by a stimulus and the time to reach habituation. Given the time-locked habituation process it is possible that the IDS led to reduced habituation, when compared with the ADS of Nazzi et al., meaning that children were not fully habituated by end of the habituation phase, which resulted in a familiarity rather than a novelty effect.

However, as mentioned by Houston-Price and Nakai (2004, p. 344), "The direction of the looking preference is largely irrelevant when infants' discrimination ability or recognition memory is of primary interest; any deviation from random behaviour indicates that a difference between the stimuli has been detected". With this in mind, the dialect discrimination ability of BE five month old infants is highly robust. What is not clear from these results is whether infants are basing this decision upon knowledge specific to their own particular dialect, simply allowing them to discriminate it from another variety, or whether they have a more general ability, allowing them to discriminate between any dialects in their native language. In the latter case then infants of the same age and background should be capable of demonstrating a similar ability when presented with two unfamiliar BE accents, such as Scottish and Welsh dialects for example.

Experiment 9: Early regional accent discrimination at five months

The aim of this experiment is to establish whether infants possess the general ability to distinguish between any dialects of their native language. Whilst Experiment 8 demonstrated that infants are capable of distinguishing between their native and a non-native dialect, this experiment examines whether infants can discriminate between two unfamiliar regional dialects. In this case infants raised in the West-Country will be presented with Welsh English (as used in Experiment 8) and Scottish English dialects, which have different phonetic (see Wells, 1982) and intonation patterns (Mayo, Aylett and Ladd, 1997; Walters, 2001).

Participants

Twenty healthy monolingual infants (13 males and seven females) with a mean age of 5.04 months (range 4.26 – 5.93) participated in this study, all of whom were raised in the West Country region of England from birth. Apart from two of the infants whose parent(s) originated from the North of England, both parents of the children also originated from either the West Country or the South of England. In all cases parents reported that the children had no exposure to Welsh or Scottish accented speakers. Post-hoc analyses showed that there was no significant effect of the parents' origins on the infant's discrimination scores, $F(1,16) < 1$. Six additional infants were excluded from the study due to crying or failure to pay attention to the lights or sounds used in the experiment (4), or because at least one parent originated from outside England (2).

Stimuli

As Experiment 8, except that the passages originally spoken by the four Plymouth speakers in Experiment 8 were re-recorded by four female Scottish accented speakers (due to restrictions in speakers' availability, two were from Glasgow, and two from Edinburgh, aged 20, 20, 30 and 32 years). All speakers were resident in either Edinburgh or Glasgow until 20 years of age. The average duration for all stimuli passages was 20.95 seconds (Welsh passages – 19.89, Scottish passages – 22.01).

Dialect characteristics

As for many cities in the North of the UK, nuclear rises are very common in Glasgow. The intonation is characterised by a typical rise evidenced by a pitch increase at the accented syllable, followed by a plateau: it remains high until the very near edge of the phrase, and then falls again (Mayo et al., 1997; Cruttenden, 1995). In Edinburgh the intonation system is slightly different as declarative sentences usually involve a succession of falling tones (Cruttenden, 1995). However, at the segmental level, the two dialects share common features, as all other dialects of Scotland (Hughes and Trudgill, 1988, p. 76). The vowels /ɪ/ and /u/ are more central, the diphthong /au/ found in "house" is produced as the monophthong /u/, /o/ and /u/ are sometimes replaced by /e/ (as in "home" and "do"), and /a/ by /ɛ/ (as in "arm"). In addition there is no h-dropping, and /t/ is often realised as a glottal stop. As for the stimuli of Experiment 8, these passages were analysed by a trained phonetician as well as being rated by eight naive adult listeners. The phonetician reported that the intonation patterns were recognisable as Scottish, but not particularly representative of the Edinburgh/Glasgow distinction as the stimuli resulted from read speech. Results obtained in the accent identification scores show that Scottish passages were identified as such with a mean accuracy of 91.0% (ranging from 75% to 100%) with a mean confidence of 3.34. Erroneous identifications were evenly split between reports of Plymouth and Welsh accents (three each, out of 64 possible responses). In a supplementary question to the original rating task, when the listeners identified a particular speaker as Scottish they were then asked to decide whether they were from Glasgow or Edinburgh, and then rate their confidence in this decision. In this case listener's identification performance was not significantly above chance. Glaswegian sentences were identified with a mean accuracy of 48.4% (exact binomial calculation: $p = .13$) with a mean confidence of 2.01, whilst Edinburgh sentences slightly better with a mean accuracy of 66.7% ($p = .064$) and a mean confidence of 1.75. Therefore it would appear that adult listeners were capable of accurately identifying the speakers used in this experiment as either Welsh or Scottish, but were not capable of making any finer distinctions within the Scottish dialects.

Procedure

The procedure was the same as that used in Experiment 8, apart from the replacement of the Plymouth stimuli with the Scottish stimuli, resulting in Welsh and Scottish habituation conditions.

Results

Figure 33 shows the mean looking times for the Scottish and Welsh dialect passages, with an average looking time of 8.19 seconds for the habituated accent, and 7.93 seconds for the non-habituated accent. Of the twenty infants tested ten had longer looking times for the habituated accent than the new accent. Comparing dialects, six out of ten infants habituated to the Welsh speech had longer looking times to that accent. For the Scottish dialect this dropped to four out of ten.

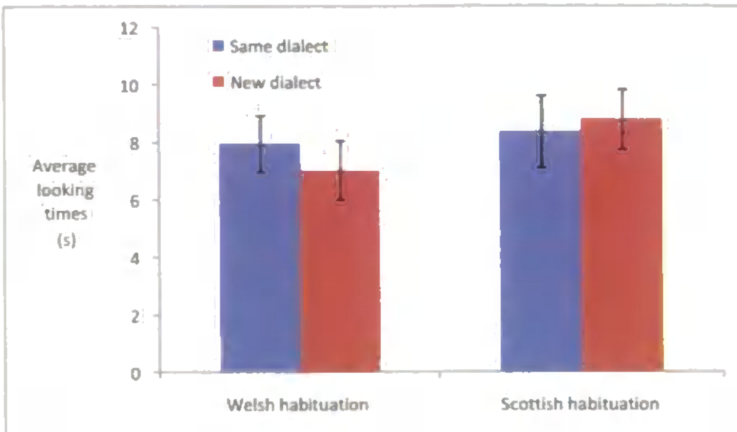

Figure 33: Mean looking times to the habituated and new accent, broken down between conditions.

A 2 X 2 repeated measures ANOVA was carried out on the looking times with a within-participants variable of dialect status (same vs. new accent) and a between-participants variable of dialect group, that is, the accent children were habituated to (Welsh vs. Scottish). This showed that neither dialect status, $F(1,18) < 1$, nor accent group, $F(1,18) < 1$ were significant, and that there was no significant interaction between the two, $F(1,18) = 1.11$, $p = .31$, $\eta^2 = .06$.

Null results in experimental psychology are commonly found and it is necessary to ascertain their origins. The sample size used in this study is very similar to the ones usually tested by previous researchers working with young infants in comparable settings (16 infants per condition in Ramus, Hauser, Miller, Morris and Mehler, 2000; 24 infants per condition in Mattys, Jusczyk, Luce and Morgan, 1999). However, in order to verify that the null result observed in Experiment 9 is not the result of the sample size, confidence intervals were calculated for Experiments 8 and 9 and the overlap between the two experiments were compared, as suggested by Smith and Bates (1992). In Experiment 8, the 95% confidence interval was .3 to 3.24, and the 95% confidence interval in Experiment 9 was -1.06 to 1.58. The overlap between the two experiments was 29% and, given that the confidence interval for Experiment 9 contained the value 0 whereas the confidence interval for Experiment 8 did not, it seems reasonable to conclude that the sample sized used in both experiments was sufficient to detect any effects.

Discussion of Experiment 9

Experiment 9 suggests that infants at five months of age do not discriminate between two unfamiliar varieties of their native language. This finding, together with the results of Experiment 8, suggests that infants do not have general discrimination abilities for regional varieties of their native language, but rather that, during the first few months of life, they have learnt something specific about their home accent that allows them to distinguish it from other regional variations. However, at this point it is not clear whether infants do not have the capability to distinguish between unfamiliar accents, or whether they represent accents as belonging to two distinct categories: one made up of their home accent, and another one entailing any other variety. This could explain why older children make use of accents in speech in order to guide social behaviour (Kinzler et al., 2007), so that they will favour those that fall into their home accent category over those that form part of the "any other accent" category. It must be noted that this early ability mirrors strongly what adults can do in accent perception tasks, that is, we are usually more accurate to identify and categorise the dialects we have a greater experience with than those we are less familiar with. For example, Van Bezooijen and Gooskens (1999) asked Dutch listeners to categorise speakers by country, region and province. Results showed that the mean accuracy was 90% for categorising speakers by country, but dropped to 60% for regions and 40% for provinces, showing that listeners do not have access to a fine-grained level of detail in perceiving accents. Another study by Clopper and Pisoni (2004) tested accent identification and categorisation in American students with six different American English dialects. They found that correct identification was at 31% only, however categorisation was above chance level, and was more accurate for students who had been geographically mobile rather than for students who had lived in the same area all their life. Anecdotally, Canadian colleagues in the UK are very often mistaken for

Americans, and a lot of British English listeners find it hard to distinguish between Irish and Scottish accents.

What cues did infants rely on to identify their home accent against the Welsh English dialect in Experiment 8? One obvious set of features that could be used are the supra-segmental prosodic information, given the well established importance of prosody in early acquisitions (e. g. Mattys et al., 1999; Nazzi, Floccia and Bertoncini, 1998). This was also suggested by Nazzi et al. (2000) who reported that five month old American infants could discriminate AE and BE. Acoustic analyses on a subset of their stimuli confirmed that, as described in Bollinger (1989), sentence initial pitch values were higher for British English sentences than for American English sentences, and that British sentences tended to have a terminal rise more often than American sentences.

However, Diehl et al. (2006) who reported preference for Australian English over American English in six month old American children, suggest that infants might focus rather on segmental cues rather than on supra segmental cues, such as the vowel space or the rhotic-non rhotic distinction between these two varieties of English. To support this claim, they report that no preference was observed when low pass filtered versions of the accented stimuli were presented to six month-old American infants. Low pass filtered speech (at 400 Hz) tends to preserve all prosodic information and remove all phonetic details that can allow lexical identification; it is also supposed to resemble the kind of input infants are exposed to prenatally. It was concluded from this result that American infants did not pay attention to supra-segmental prosodic information in dialects, but rather to segmental information.
However, at six months of age, the amount of post-natal experience with language is such that the processing of full-spectral version of speech might be more accurate and complete than the processing of its lowest frequency components (see Cooper and Aslin, 1989, for a similar argument). Therefore, the failure exhibited by six month old American infants to prefer low pass filtered versions of AuE over AE could be due to

the presentation of this now unusual version of speech, which would hinder their full ability to process relevant information, or simply lower their level of attention towards it. Nevertheless these unpublished results may not be sufficient to accept the conclusion that infants pay more attention to the segmental aspects of speech rather to supra-segmental cues when sorting out accents.

The findings so far confirm that five month old infants are able to discriminate between two regional accents as long as their home accent is one of the accents being compared. Do infants still demonstrate this discrimination effect at seven months? As discussed earlier, there appears to be some evidence that infants in other populations "lose" this discrimination ability between six and eight months (Kitamura et al., 2006a; Kitamura et al., 2006b; Phan and Houston, 2006). However this effect may not be clear cut, and so to further investigate this possible result, an attempt to replicate these findings will be made using a discrimination task using a wide range of phonetically varied sentences, whose lexical content was specifically chosen (by Nazzi et al., 2000) to ensure that it would not correspond to infants' early vocabulary. It should be noted that one of the criticisms was that the sentences used in the Australian studies were repeated, which may have allowed the infants to focus on the similarities between sentences rather than the differences. Therefore, Experiment 10 will test for discrimination between the home accent and the Welsh English accent at seven months.

Experiment 10: Development of native accent discrimination at seven months

So far, the findings of the infant experiments have shown that infants at five months are able to discriminate between two regional accents when their home accent is present. Previous research suggests that as infants get older they "lose" this discrimination ability, but the evidence is not clear cut, especially in American infants. In addition, commenting on the finding that Australian infants lose their preference for Australian English over American English between three and six months, Kitamura et al. (2006a) suggested that it might be due to the increasing exposure to some varieties of English through the media for example, leading to a greater familiarity with these accents and accelerating the process of ignoring irrelevant surface variations. As it has been ensured that the children will not have experienced more exposure to the unfamiliar accent (Welsh English accent) from five months to seven months, it is expected that they will retain discrimination abilities for this accent as compared with their home accent. Experiment 10 will repeat the procedure of Experiment 8, but this time using seven month olds.

Participants

Twenty healthy monolingual, seven month old infants (10 male and 10 females), with a mean age of 7.36 months (range 5.90 – 8.56) participated in this study. They were selected on the same criteria as in Experiments 8 and 9. Five of these infants had one or two parents who originated from the North of England whereas the parents for the remaining 15 originated from the South West of the South of England. Again there was no effect of parents' origins on discrimination scores, $F(1,16) = 1.43$, $p = .25$, $\eta^2 = .08$. Four infants were excluded from the study due to crying and loss of attention to the lights and sounds (2), or because at least one parent originated from outside England (2).

Stimuli

The stimuli used in this experiment were identical to those used in Experiment 8.

Procedure

The procedure was identical to the procedure used in Experiment 8.

Results

Mean looking times were calculated to the two accents during the test phase and displayed in Figure 34. Thirteen of the 20 infants had longer looking times to the new accent over the habituated accent. Overall, the average looking time to the habituated accent was 6.60 s, while average looking time to the new accent was 7.97 s. Broken down in two groups, seven out of 10 infants exposed to Plymouth accented speech had longer looking times to the new accent, while six out of 10 infants exposed to Welsh English accented speech had longer looking times to the new accent.

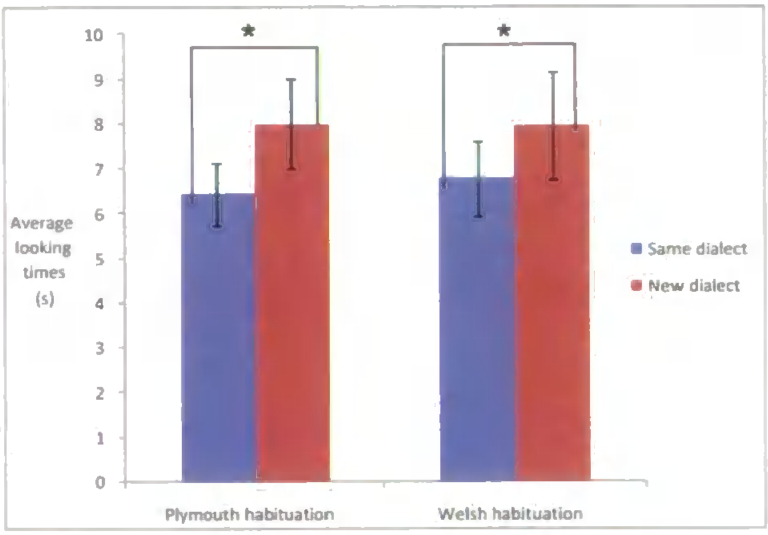

Figure 34: Mean looking times to the habituated and new accent, broken down between conditions.

A 2 X 2 repeated measures ANOVA was carried out on the data, with a within-participants variable of dialect status (same vs. new accent) and a between-participants variable of dialect group (Plymouth vs. Welsh English). There was a significant effect of dialect status, $F(1,18) = 4.48$, $p = .048$, $\eta^2 = .199$, no significant effect of dialect group, $F(1,18) < 1$, and no interaction between dialect status and dialect group, $F(1,18) < 1$.

Discussion of Experiment 10

The results of Experiment 10 suggest that, at seven months, infants from the South West of England are still able to discriminate between regional accents, with their home accent presented as part of the experiment. This does not fit with previous findings (Kitamura et al., 2006a, 2006b; Phan and Houston, 2006), which suggests that infants do "lose" the ability to discriminate regional accents between the ages of six to eight months. As mentioned above, the discrimination procedure used in this study might have been more sensitive than the preference procedure used by Kitamura et al. In addition, whereas Kitamura et al. (2006a, 2006b) have used multiple repetitions of the same simple sentences, this study has presented passages made up of different complex sentences with words presumably unknown to the children. Presenting multiple and variable exemplars (here, sentences) of the same accent has perhaps contributed to emphasize the within-category similarity, that is, the fact that all these sentences were produced with the same accent (see Floccia, Nazzi and Bertoncini, 2000; Madole and Oakes, 1999; Singh, 2008). In contrast, in Kitamura et al.'s studies infants may have been biased towards focusing on the phonetic similarity between repeating sentences.

It is worth noting that at seven months infants show longer looking times to the new rather than to the habituated accent (13 infants out of 20 showed this trend). This trend is opposite to the effect found at five months, where looking times were significantly longer to the habituated, rather than new, accent. Following Houston-Price and Nakai's (2004) review of the factors influencing novelty versus familiarity effects in HPP-related procedures, it is quite established that the older the children, the faster the completion of habituation, with all other factors being equal in Experiments 8 and 10. This leads to a better representation of the habituated accent in seven month olds, which in turn leads to a greater reaction to novelty.

Before further discussion of the implications of these findings for the development of speech perception, it was thought necessary to complete the set of studies by examining young infants' discrimination abilities for foreign accents. As stated earlier, foreign accents may not recruit the same processing mechanisms as dialects (Floccia et al., 2006; Floccia et al., 2009b; Girard et al., 2008). As suggested by Chambers (2002), children might come equipped with an innate accent-filter, which would prevent them from learning any "foreign features" (p. 121-122). Indeed, anecdotal evidence suggests that children born of immigrant, non-native speaking, parents, do not appear to learn the native language with their parent's foreign accent, whereas learning a new dialect during childhood is a common observation (e.g. Fischer, 1958; Kerswill and Williams, 1992; Starks, 2002). This foreign features filter might signal different underlying normalisation abilities for the two types of accents. Following this, it was hypothesised that seven month olds' discrimination abilities would be even more robust for distinguishing a foreign accent from their home dialect, than for distinguishing a regional variety from their home dialect as was found in Experiment 10.

Experiment 11: Regional versus foreign accent discrimination at seven months

This experiment was designed to examine whether infants are able to discriminate an unfamiliar foreign accent from their own accent. Although there is some suggestion that there may be different processing mechanisms for regional and foreign accents (Floccia et al., 2006; Floccia et al., 2009b; Girard et al., 2006), the fact that infants at this age were able to discriminate their own accent from another unfamiliar regional accent suggests that they would also be able to discriminate their own accent from an unfamiliar foreign accent. In this experiment, seven month old infants were presented with passages in their home dialect versus passages produced by French native speakers.

Participants

Twenty healthy monolingual, seven month old infants (14 male and six females), with a mean age of 7.27 months (range 6.79 – 8.10) participated in this study. They were selected on the same criteria as in all other experiments. At least one parent in three cases originated from the North of England, whereas all parents of the remaining 17 children originated from the West Country or the South of England. Again, there was no effect of parents' origins on discrimination scores, $F(1,16) < 1$. Parents reported that children hadn't had any particular experience with a French accent. Seven infants were excluded from the study due to crying and loss of attention to the lights and sounds (3), or because at least one parent originated from outside England (4).

Stimuli

The stimuli used were the same as in Experiment 8, except that the four Welsh English speakers were replaced by four French speakers (the Plymouth accented speakers were the same as in Experiments 8 and 10). Out of the four French accented female speakers, three were from the South of France and one from the North, but all of them spoke a standard Parisian dialect (speaker one, age 40, in Plymouth for three years; speaker two, age 36, in Plymouth for 12 years; speaker three, age 42, in Plymouth for 10 years; speaker four, age 39, in Plymouth for three year). The average duration for the recorded passages was 21.08 s (Plymouth passages – 20.57, French passages – 21.60).

Accent characteristics

To my knowledge, the only formal descriptions of French-accented English have focused on the segmental level. Certain English phonemes which do not exist in French are inaccurately produced such as the rounded lax vowel /ʊ/ as in "book", the ending consonant /ŋ/ of "taking" (Arslan and Hansen, 1996), and the fricatives /ð/ (as in "this") and /θ/ (as in "think"). The English /ɹ/ would be produced as its French uvular fricative equivalent, and the voice onset time values for voiceless plosive consonants would be shorter than those for English equivalents (Flege, 1984; Ladefoged, 2005; Laver, 1994).

Results obtained in the accent identification scores show that the French accented passages were identified as such with a mean accuracy of 98.4% (from 87.5% to 100%) with a mean confidence of 3.88. One participant incorrectly identified one passage and reported hearing a Plymouth accent with a confidence of 1. It appears that the stimuli were accurately selected, as naive English listeners identified them as French accented with a very high level of accuracy.

Procedure

The procedure was identical to the procedure used in Experiment 8.

Results

Mean looking times were calculated to the two accents during the test phase and displayed in Figure 35. Seven of the 20 infants had longer looking times to the new accent over the habituated accent. Overall, the average looking time to the habituated accent was 6.08 s, while average looking time to the new accent was 5.66s. Broken down in two groups, four out of 10 infants exposed to Plymouth accented speech had longer looking times to the new accent, while three out of 10 infants exposed to Welsh English accented speech had longer looking times to the new accent.

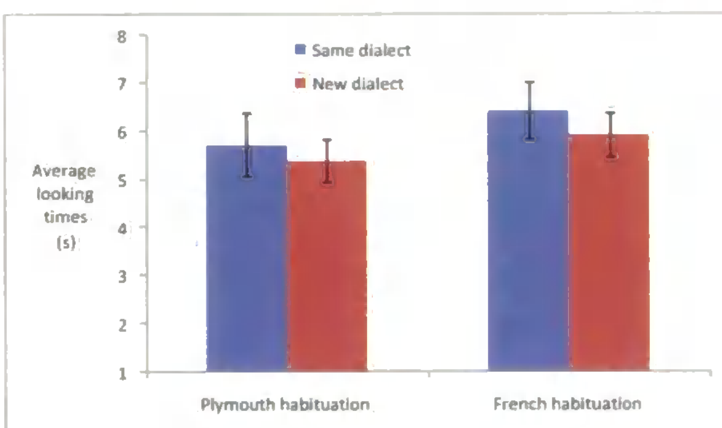

Figure 35: Mean looking times to the habituated and new accent, broken down between conditions.

A 2 X 2 repeated measures ANOVA was carried out on the data, with a within-participants variable of accent status (same vs. new accent) and a between-participants variable of accent group (Plymouth vs. French). There was no significant effect of accent status, $F(1,18) < 1$, no significant effect of accent group, $F(1,18) < 1$, and no interaction between the two variables, $F(1,18) < 1$.

As with the comparison of Experiments 8 and 9, it appeared necessary to confirm here that the null result in this experiment, compared with the effect found in Experiment 10, was not due to the sample size. Confidence intervals and percentage overlap were calculated between Experiments 10 and 11. In Experiment 10, the 95% confidence interval was -2.68 to -.05, and the 95% confidence interval in Experiment 11 was -.49 to 1.34. The overlap between the two experiments was 11% and, given that the confidence interval for Experiment 11 contained the value 0 whereas the confidence interval for Experiment 10 did not, it seems reasonable to conclude that the sample sized used in both experiments was sufficient to detect any effects.

Discussion of Experiment 11

Surprisingly, seven month olds infants who had been shown to discriminate their home accent from a regional variation in Experiment 10, failed to provide evidence of discrimination between their home accent and a foreign, French, accent. This is even more surprising considering that adult listeners asked to identify the four accents used in this study (Plymouth, Welsh English, Scottish and French), were more accurate in detecting the French accent than any other one. In addition, Kinzler et al. (2007) had reported evidence of discrimination for a foreign accent in 10 month old American infants in a social choice situation. Why did seven month olds infants fail in this task?

The most likely explanation is that infants at least until the age of seven months mainly focus on the supra-segmental properties of continuous speech. This would explain why they detect a change between two dialects which are characterised by two different intonation systems as in Experiment 10 (Plymouth versus Welsh English, see Walters, 2001: Bolinger, 1989). However they would not necessarily distinguish the French accented passages from the Plymouth passages because the French speakers, who were all experienced English speakers having all improved their English in the South West, did a great job in mimicking the intonation system of the West Country accent. In contrast, at 10 months of age which is the age tested by Kinzler et al. (2007), infants are engaged in the processing of segmental information as demonstrated by their earlier ability to learn words from the speech stream (e.g. Jusczyk and Aslin, 1995) or by the reorganisation of consonant perception (e.g. Werker and Tees, 1984). Therefore at that age infants can probably detect a foreign accent by relying on its segmental characteristics. This claim would need further support, for example by testing infants' discrimination of foreign accent with less experienced speakers, who would not have acquired the child's native language's intonation system. In order to verify that the French speakers' prosody was representative of South West English, adult listeners were presented with low pass filtered versions of the stimuli (to remove phonetic information but retain prosody). In a task similar to that described in the method section of Experiment 8, the stimuli was low pass filtered at 300 Hz using Praat, and the 32 resulting passages were presented to eight adult participants (mean age 43 years, five females). As compared with the procedure described in Experiment 8, two other differences were that 1, when participants had identified the Scottish accent, there were not asked further whether they thought the speakers were from Glasgow or Edinburgh, and 2, the label for the Plymouth speaker was changed into "West Country" speaker, to provide the listeners with a wider perceptual category (as Plymouth accent by itself is not easily identifiable, especially not in speakers with moderate accents as those we chose). Participants were not able to successfully recognise the Plymouth, Welsh or Scottish stimuli, performing at chance level (25% correct identification): 32.8% for the Scottish speakers ($t(7) = 1.49$, mean confidence = 1.49; confidence varied from 1 (not confident) to 4 (very confident)), 39.1% for the Welsh speakers ($t(7) = 2.05$; mean confidence = 1.58), and 39.1% for the West Country speakers ($t(7) = 1.76$; confidence = 1.61). However, for the French stimuli, they performed significantly above chance (48.4% correct identification, $t(7) = 3.23$, $p = .014$; mean confidence = 1.70). However this seemed to be mainly due to two speakers out of four (main effect of speakers on identification scores: $F(3, 21) = 2.82$, $p = .064$). Indeed two speakers were identified only 25% and 37.5% correctly, which is similar to what was found with Welsh speakers for example, whereas the two others were at 67.5% and 62.5% correct identification. These results suggest that adults are not very efficient in using prosody to sort out regional dialects, but they can use this information to identify foreign accents. Indeed the contribution of prosody to the characterisation of foreign accents has been demonstrated for example by Vieru-Dimulescu and Boula de Mareüil (2005). These authors manipulated the prosody in read samples of Italian and Spanish, and asked native (Italian and Spanish) and non-native (French) listeners to identify the accent in each sentence. For example, the prosody in a sentence read in Italian by a native Italian speaker was replaced by the prosody of a Spanish speaker. Results showed that listeners could identify all accents above chance level, suggesting that prosody (and particular rhythm as shown by the acoustic measures they performed on the corpus) plays an important role in the perception of foreign accents.

Returning to the infant results of this study, it would appear that if infants are relying on prosody, then they should have been able to discriminate French from Plymouth accented speech and fail to discriminate Welsh from Plymouth accented speech, however the infants demonstrated the opposite effect. Perhaps, in addition to prosody, the infants are also paying attention to segmental information, or that they are attending to something that adults no longer pay attention to. It could be possible that, as adults, we have learnt to attend to certain features of prosody that are similar between Welsh and Plymouth, and pay greater attention to foreign prosody. These findings with adults do not necessarily mean infants do not focus on prosody, but further investigation would be required to try and ascertain what features they are attending to.

Discussion of Experiments 8 to 11

Thus far this study has investigated five and seven month old infant's abilities to discriminate between different familiar and unfamiliar regional accents. It has been shown that, at five months, infants are able to discriminate two regional accents only when their home accent is one of them, when faced with two unfamiliar regional accents they are unable to differentiate between them. In contrast to other findings (Kitamura et al., 2006a, 2006b; Phan and Houston, 2006), it was found that this discrimination ability was still evident at seven months. However, at seven months infants were unable to discriminate a foreign accent from their own accent, which is surprising considering their success discriminating an unfamiliar regional accent from their own accent, and also other findings that demonstrate infants and older children can use accented related information to guide social behaviours (Kinzler et al., 2007).

As seven month old infants have been shown to be able to discriminate between their own and another regional accent, it is interesting to investigate this further in time, and, in particular, to examine how normalising abilities for continuous speech develop. Schmale and Seidl (2009) have shown that at nine months infants cannot recognise new words in continuous speech when two different accented (Spanish) speakers are used, but they can at 13 months. This can sound paradoxical given that no discrimination of a foreign accent versus the home accent at seven months was found (Experiment 11), and it was hypothesised that this was due to children paying attention to the intonation envelopes of the sentences, rather than to fine-grained phonetic information. However at nine months, and in word segmentation tasks, success is only possible if phonetic information is accessed and normalised. So it is possible that at nine months children are unable to represent invariant phonetic information when a foreign accent is used (but at 13 months they can). Schmale and Seidl's study raises a new question: would the word segmentation results be similar if children were presented with regional accents? Again what is needed to succeed in that task is the ability to retrieve phonetic information. This study has established that, at seven months, infants can discriminate Plymouth/Welsh, which means, if this reasoning is maintained, that they used intonation to distinguish these two varieties. So in a word segmentation task, would the differences in intonation still be so salient that it would prevent them from focusing on phonetics? Or do they move onto a phonetic mode of perception anyway, and if so, would they normalise the dialectal information?

In order to investigate these questions, infants will be presented with two regional English accents, Plymouth and Scottish, and whether they are able to extract words from continuous speech between these two accents will be examined in Experiment 12. To act as a control for Experiment 12, children will be presented with a foreign accent (German) versus the home accent in Experiment 13, with the aim of replicating Schmale and Seidl's results in our settings.

It is expected that, if infants have not yet developed the ability to process and ignore accent related intonation differences for all accents, then they will not be able to successfully segment continuous speech when a regional or foreign accent is present (as demonstrated by Schmale and Seidl, 2009). However, if infants learn to process regional and foreign accents in different ways, then it is expected that infants will be able to successfully segment continuous speech when a regional, but not a foreign, accent is present.

Chapter 7

Word segmentation in continuous accented speech

So far, Experiments 8 to 11 have investigated infants' discrimination abilities for different types of regional and foreign accents. The next experiments will look at infants' developing abilities to successfully segment continuous speech into word units, and how the presence of accents affects these abilities.

Experiment 12: Regional accents and word segmentation at 10 months

This experiment investigates 10 month old British English infants' word segmentation abilities when an unfamiliar regional accent is paired with their home accent. The infants will be presented with passages containing a target word, and will then be presented with isolated examples of the target words and the new words to examine whether they can successfully segment words while ignoring accent related indexical information. However, this study will differ from Schmale and Seidl's study, in that it will use the passage-word version of the word segmentation paradigm, instead of the word-passage version. That is, in this study, infants will be presented with passages uttered or not in an unfamiliar dialect, containing two target words, and then tested on their recognition of these words presented in isolation. In Schmale and Seidl's study, the reverse paradigm was used. It appeared that the passage-word version was a more relevant choice if one wants to investigate children's perceptual abilities for unfamiliar dialects or accents, as it provides them with a wide range of cues, from segmental to suprasegmental, and thus reveals a broader picture of their abilities to normalise this information. Conversely, by presenting them with words in isolation first, one puts the infants in a segmental mode of perception. Therefore if they do not recognise the same words in subsequent passages, it could be because supra-segmental information suddenly available masks the fine-grained information that they were encoding with isolated words.

Similarly to Schmale and Seidl's study, the four possible combinations of habituation accent will be tested, that is, Plymouth-Plymouth, Plymouth-Scottish, Scottish-Plymouth and Scottish-Scottish. The rationale was to look for possible transfer effects from one accent to the other. If children are able to normalise dialect-related variations, one would expect correct identification of words in all conditions. However, if children's processing of dialect information prevents them from extracting an abstract representation of phonetic information, then one would expect them to fail in all cross-dialect conditions, that is, the Plymouth-Scottish or Scottish-Plymouth conditions. However, these two conditions are not symmetrical, because in the Plymouth-Scottish condition, infants are given all the familiar supra-segmental and segmental elements they need to extract new words, whereas in the Scottish-Plymouth condition, they have to process a new intonation system and new phonological rules. Therefore it could be expected to find a better performance in the Plymouth-Scottish condition rather than in the Scottish-Plymouth condition. Finally, the Scottish-Scottish condition might lead to successful word recognition in infants simply because children could perform sound pattern matching between the passages and the isolated words, whatever their normalisation abilities might be.

Stimuli

Stimuli consisted of two components; passages containing the target words, and words lists, made up of isolated target words. In total, four target words were selected (carriage, dialect, pasture, tourist), and these were split into two word pairs; carriage-pasture and dialect-tourist. These words were selected as they were likely to carry Scottish dialect related information that would distinguish them from each other when spoken in the accents used in this study. In particular, these words contain diphthongs, and the Scottish phonological system is very different from the South of England phonological system regarding these sounds, in that, as described in Experiment 9, the Scottish system contains less, such as the diphthong /au/ found in "house" is replaced by the monophthong /u/, /o/ and /u/ are sometimes replaced by /e/

(as in "home" and "do"), and /a/ by /ɛ/ (as in "arm"). For each target word, a passage made up of four unrelated sentences was constructed, and within the passage the target word appeared in each sentences once (see appendix B). Each passage was constructed so that each corresponding sentence was a similar length, and the position of the target word in each sentence varied within the passage, but were roughly in the same position in the corresponding passage (e.g. the first sentence in each passage had the target word in the position two in the sentence). The word lists were made up of 15 isolated examples of the target word. The passages were recorded by two female speakers with a Plymouth accent (aged 40 and 31, both born and raised in Plymouth) and two Scottish speakers, who had previously recorded stimuli for Experiment 9 (one of the speakers was from Edinburgh and the other from Glasgow, see Experiment 9 for discussion on differences between speakers). All four speakers recorded all the passages and word lists, and presentation of speakers was counterbalanced. The speakers were again recorded in child oriented speech, to make the passages as interesting as possible for the infants. For the word lists, the speakers were instructed to say the word several times with different intonation each time. The best five examples were selected and were copied to make 15 examples of each target word, and saved in a sound file, to make a total of four sound files, one for each target word list. Recordings were made using a digital dictaphone and microphone, using 16 bit, 44100Hz sampling rate. The average duration for the passages was 13.64 seconds (Plymouth passages – 13.51, Scottish passages – 13.77) and the average duration for the word lists was 18.81 seconds (Plymouth word lists – 19.32, Scottish word lists – 18.30). (For a complete list of passages and word lists, see appendix B).

Participants

Sixteen healthy monolingual infants (eight males and eight females) with a mean age of 10.33 months (range 9.90 – 10.79) participated in this study, all of whom were raised in the West Country region of England from birth. For all but three of the infants (whose parent(s) originated from the North of England), both of the parents of the children originated from either the West Country or the South of England. In all cases parents reported that the children had no particular exposure to Scottish accented speakers. Post-hoc analyses showed that there was no significant effect of the effects of the parents' origins on the infant's discrimination scores ($F(1,10) < 1$). Three additional infants were excluded from the study due to crying or failure to pay attention to the lights or sounds used in the experiment.

Procedure

The head turn preference procedure was used that was similar to that used in Experiment 8, except the stimuli that were presented to the infants differed. The habituation stimuli were replaced with two passages that contained either the target word pair "carriage-pasture" or "dialect-tourist". Passages were presented to the infant until they had accumulated 45 seconds of looking time to each passage. The passages were either produced in a Plymouth or a Scottish accent, depending on the condition the infant was allocated to. In total there were four conditions; Plym-Plym, Plym-Scot, Scot-Plym and Scot-Scot (for each condition the accent mentioned first is the accent the passages were recorded in, the second accent mentioned is the accent the word lists were recorded in). Once the looking times were achieved for each passage, infants continued into the test phase, where they were presented with four word lists, the target word pair they had been presented with before, and the other word pair that was new to them. Each word list was presented three times, but each word list was heard once before a word list was repeated, and each word list was heard twice before a word list was presented for a third time. During each of the test phase word lists, the infants' looking times were recorded by the experimenter, with average looking times for each word calculated by the computer control program.

Results

Figure 36 shows the mean reaction times to the target and new word lists, broken down between conditions. Overall, average looking times to the target word lists was 9.88 seconds, and to the new word lists was 8.48 seconds. Of the sixteen infants tested, 10 had longer average looking times to the target word lists than for the new word lists.

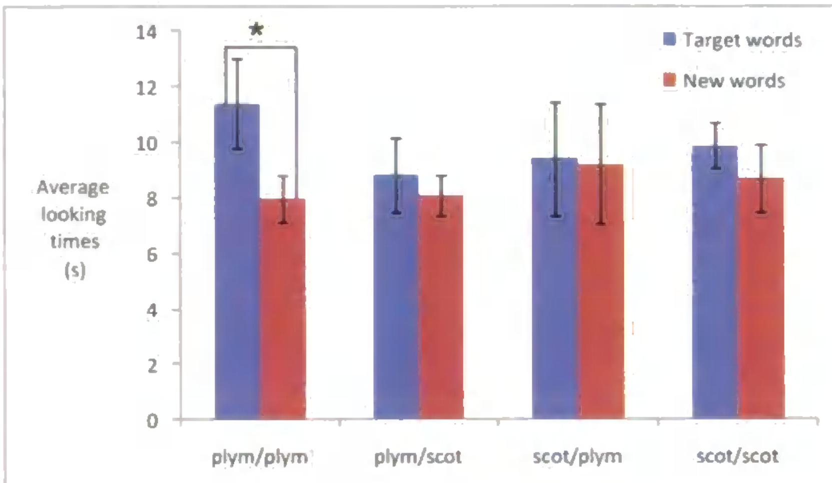

Figure 36: Average looking times to the target and new word lists, broken down between conditions.

Comparing each condition, four out of four infants in the Plym-Plym condition had longer looking times to the target word lists than the new word lists (target words average – 11.40s, new words average – 7.96), two out of four infants in the Plym-Scot condition had longer looking times to the target word lists than the new word lists (target words average – 8.83, new words average – 8.07), one out of four infants in the Scot-Plym condition had longer looking times to the target word lists than the new word lists (target words average – 9.41, new words average – 9.20), and three out of four infants in the Scot-Scot condition had longer looking times to the target word lists than the new word lists (target words average – 9.87, new words average – 8.67).

A 2 X 4 repeated measures ANOVA was carried out on the looking times, with a within-participants variable of word list status (target vs. new) and a between-participants variable of condition (Plym-Plym, Plym-Scot, Scot-Plym, Scot-Scot). There was a significant effect of status, $F(1,12) = 6.05$, $p < .05$, $\eta^2 = .34$, with significantly longer average looking times to the target word lists than to the new word lists. There was no significant effect of condition, $F(3,12) < 1$, and no interaction between status and condition, $F(3,12) = 1.54$, $p = .26$, $\eta^2 = .28$.

As there is no interaction between status and condition, no further analysis would be necessary. However as this study is interested in whether the infants were able to recognise words successfully within each condition, and because there is little data for each condition (which would explain perhaps the lack of significant interaction between status and condition), further analysis were carried out, as reported below. For these reasons, the results of this analysis need to be interpreted with caution.
Each condition was then analysed separately using a repeated measures ANOVA, to see whether there was any evidence of segmentation. In the Plym-Plym condition, there was a significant effect of status, $F(1,3) = 12.03$, $p < .05$, $\eta^2 = .8$. There was no significant effect of status in the Plym-Scot, $F(1,3) < 1$, Scot-Plym, $F(1,3) < 1$, or Scot-Scot, $F(1,3) < 1$.

Next, 2 X 2 comparisons were carried out between the conditions. Between the Plym-Plym and Plym-Scot conditions, there was a significant effect of status, $F(1,6) = 7.01$, $p < .05$, $\eta^2 = .54$, no effect of condition, $F(1,6) <1$, and no interaction between status and condition, $F(1,6) = 2.84$, $p = .14$, $\eta^2 = .32$. Between the Plym-Plym and Scot-Plym conditions, there was a significant effect of status, $F(1,6) = 7.11$, $p < .05$, $\eta^2 = .54$, no effect of condition, $F(1,6) < 1$, and no interaction between status and condition, $F(1,6) = 5.57$, $p = .06$, $\eta^2 = .48$. Between the Plym-Plym and Scot-Scot conditions, there was a significant effect of status, $F(1,6) = 7.72$, $p < .05$, $\eta^2 = .56$, no effect of condition, $F(1,6) < 1$, and no interaction between status and condition, $F(1,6) = 1.79$, $p = .23$, $\eta^2 = .23$. Between the Plym-Scot and Scot-Plym conditions, there was no effect of status, $F(1,6) < 1$, no effect of condition, $F(1,6) < 1$, and no interaction between status and condition, $F(1,6) < 1$. Between the Plym-Scot and Scot-Scot conditions, there was no effect of status, $F(1,6) = 1.16$, $p = .32$, $\eta^2 = .16$, no effect of condition, $F(1,6) < 1$, and no interaction between status and condition, $F(1,6) < 1$. Between the Scot-Plym and Scot-Scot conditions, there was no effect of status, $F(1,6) < 1$, no effect of condition, $F(1,6) < 1$, and no interaction between status and condition, $F(1,6) < 1$.

Discussion of Experiment 12

Experiment 12 tested infants' abilities to extract new words from continuous speech and recognise them when presented in isolation. The dialect of the speakers producing the passages or the dialect of the speakers producing the isolated words was varied (Scottish or Plymouth), to examine infants' abilities to normalise dialect-related information. This was inspired by a study by Schmale and Seidl (2009), who presented infants with foreign accented speech versus home dialect, and reported a failure to recognise word in continuous speech at nine months, but not at 13 months.

The results of Experiment 12 suggest first that the infants who heard only Plymouth accented speakers (Plym-Plym condition) were able to successfully segment continuous passages to identify new words replicating the seminal study by Jusczyk and Aslin (1995) and many others since then (Houston and Jusczyk, 2000; Singh et al., 2004; Singh, 2008; Polka et al., 2008, 2003; Nazzi et al., 2008, 2006; Schmale and Seidl, 2009). However, the infants did not show any evidence of word segmentation when the unfamiliar regional accent was present. More data would be needed to strengthen the results, however a close inspection of Figure 36 suggest a few comments: first, the worse condition for these children seems to be the Scottish-Plymouth condition, whereas the Scottish-Scottish and the Plymouth-Scottish conditions might lead to significant word recognition with further data. These observations suggest, as hypothesised earlier, that transfer from one accent to the other might be possible when the familiar dialect is presented first, because it provides the children with all their most familiar supra-segmental and segmental cues usable for word segmentation. Second, the apparently better performance of children in the Scottish-Scottish condition as opposed to the Scottish-Plymouth condition suggests that perhaps in the former condition, children can use sound pattern matching to recognise the Scottish accented words from the Scottish accented passages. In order to succeed in the Scottish-Plymouth condition however, it would seem necessary to normalise the phonetic information to accommodate for dialect variation: a simple pattern sound matching might not prove sufficient.

In summary, Experiment 12 suggests that, although infants are able to perform word segmentation in continuous speech by 10 months, they have not had either sufficient exposure to accented related variations, or perhaps they are not yet experienced enough with segmentation techniques to allow them to transfer this ability to an unfamiliar accent. However there are too few data points in each condition, so these results need to be used with caution.

In order to examine how the presence of a foreign accent affects segmentation, a further experiment was carried out as a comparison to Experiment 12. This experiment acted as a control to Experiment 12 to replicate and extend the findings of Schmale and Seidl (2009), which found that infants at nine months could not segment continuous speech when at least one foreign accented speaker was used to produce the stimuli, but could at 13 months. Together with the results of Experiment 12, one would not expect 10 month old infants to be able to segment continuous speech if one or two foreign accented speakers were presented.

Experiment 13: Foreign accents and word segmentation at 10 months

This experiment investigates 10 month old British English infants' segmentation abilities when an unfamiliar foreign accent (German accent) is paired with their home accent, in a similar way to Experiment 12. The infants in Experiment 12 were not able to segment continuous speech when a regional accent was present, and one would not expect them to be able to segment speech when a foreign accent was present.

As in Experiment 12, it is possible to draw the same hypotheses regarding asymmetries between the different conditions: the German-Plymouth condition might be more difficult to process than the Plymouth-German condition, simply because in the former condition infants are learning the new words by listening to all the familiar cues they need to segment speech. In addition, the German-German condition might be easier than the German-Plymouth one because no transfer across accent is needed to recognise the words, a simple acoustic matching might be sufficient.

Stimuli

As Experiment 12, except that the two Scottish speakers were replaced with two German speakers (speaker one - aged 34 years, in Plymouth for two years; speaker two - aged 19, in Plymouth for two months).

Accent characteristics

Similarly to English, German is an Indo-European, stress timed language (Bauer, 2007). A study by Grabe (1998) utilised acoustical analysis of English and German speech, in regard to pitch accent realisation, and found that German differed from English in that falling accents are truncated and do not become steeper but rather end earlier. In comparison with English, where both rises and falls are "compressed", both contours become steeper so that the rise and fall can be completed in a shorter time span.

Looking at the segmental properties of German speech, using the speech accent archive website (Weinberger, 2003), German speakers tend to display final obstruent devoicing and non aspiration in relation to consonants, and they also tend to display shortened and raised vowels.

Participants

Sixteen healthy monolingual infants (five males and 11 females) with a mean age of 9.94 months (range 9.31 – 10.89) participated in this study, all of whom were raised in the West Country region of England from birth[2]. For all but six of the infants (whose parent(s) originated from the North of England), both of the parents of the children also originated from either the West Country or the South of England[3]. In all cases parents reported that the children had no exposure to German accented speakers. Post-hoc analyses showed that there was no significant effect of the effects of the parents' origins on the infant's discrimination scores ($F(3,8) = 1.85$, $p = .22$, $\eta^2 = .41$). Twelve additional infants were excluded from the study due to crying or failure to pay attention to the lights or sounds (11), or one of the parents originated from outside England (1).

Procedure

The procedure used in this experiment was identical to that used in Experiment 12, except the two Scottish speakers were replaced with two German speakers.

Results

Figure 37 shows the mean reaction times to the target and new word lists, broken down between conditions. Overall, average looking times to the target word lists was 9.76 seconds, and to the new word lists was 8.31 seconds. Of the 16 infants tested, 10 had longer average looking times to the target word lists than for the new word lists.

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[2] The data collected for the four infants in the Plym-Plym control condition in Experiment 12 have been used as the control condition in Experiment 13 as well.
[3] Due to an experimental error, three infants were included whose parent(s) originated from outside England, however removing their data does not affect the results.

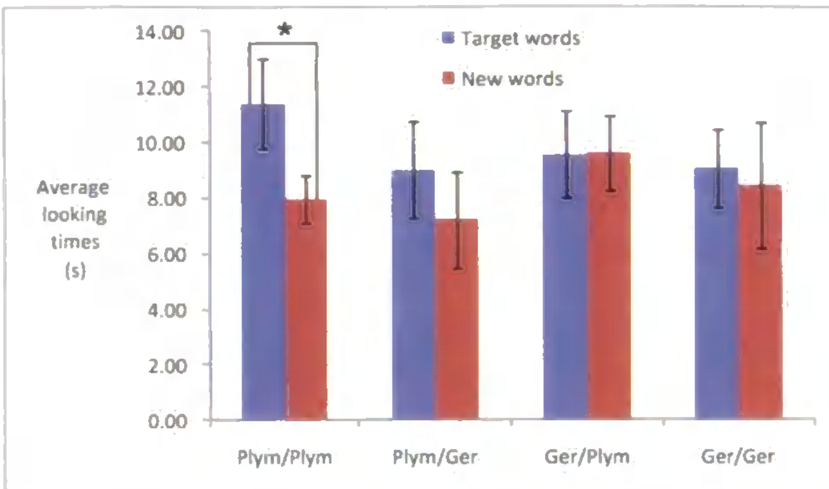

Figure 37: Average looking times to the target and new word lists, broken down between conditions.

Comparing each condition, four out of four infants in the Plym-Plym condition had longer looking times to the target word lists than the new word lists (target words average – 11.40s, new words average – 7.96), two out of four infants in the Plym-Ger condition had longer looking times to the target word lists than the new word lists (target words average – 9.01, new words average – 7.21), two out of four infants in the Ger-Plym condition had longer looking times to the target word lists than the new word lists (target words average – 9.57, new words average – 9.60), and two out of four infants in the Ger-Ger condition had longer looking times to the target word lists than the new word lists (target words average – 9.06, new words average – 8.46).

A 2 X 4 repeated measures ANOVA was carried out on the looking times, with a within-participants variable of word list status (target vs. New) and a between-participants variable of condition (Plym-Plym, Plym-Ger, Ger-Plym, Ger-Ger). There was no significant effect of status, $F(1,12) = 4.227$, $p = .06$, $\eta^2 = .26$, no significant effect of condition, $F(3,12) < 1$, and no interaction between status and condition, $F(3,12) = 1.163$, $p = .36$, $\eta^2 = .23$.

As in Experiment 12, as there is no interaction between status and condition, no further analysis would be necessary. However for the same reasons reported previously, it was decided to look at conditions separately, and, again, the results of this analysis need to be interpreted with caution.

Each condition was then analysed separately using a repeated measures ANOVA, to see whether there was any evidence of segmentation. In the Plym-Plym condition, there was a significant effect of status, $F(1,3) = 12.03$, $p < .05$, $\eta^2 = .8$. There was no significant effect of status in the Plym-Ger, $F(1,3) = 1.04$, $p = .38$, $\eta^2 = .26$, Ger-Plym, $F(1,3) < 1$, or Ger-Ger, $F(1,3) < 1$.

Next, 2 X 2 comparisons were carried out between the conditions. Between the Plym-Plym and Plym-Ger conditions, there was a significant effect of status, $F(1,6) = 6.66$, $p < .05$, $\eta^2 = .53$, no effect of condition, $F(1,6) < 1$, and no interaction between status and condition, $F(1,6) < 1$. Between the Plym-Plym and Ger-Plym conditions, there was no effect of status, $F(1,6) = 3.91$, $p = .1$, $\eta^2 = .4$, no effect of condition, $F(1,6) < 1$, and no interaction between status and condition, $F(1,6) = 4.05$, $p = .09$, $\eta^2 = .4$. Between the Plym-Plym and Ger-Ger conditions, there was no effect of status, $F(1,6) = 5.68$, $p = .054$, $\eta^2 = .49$, no effect of condition, $F(1,6) < 1$, and no interaction between status and condition, $F(1,6) = 2.8$, $p = .15$, $\eta^2 = .32$. Between the Plym-Ger and Ger-Plym conditions, there was no effect of status, $F(1,6) < 1$, no effect of condition, $F(1,6) < 1$, and no interaction between status and condition, $F(1,6) < 1$. Between the Plym-Ger and Ger-Ger conditions, there was no effect of status, $F(1,6) = 1.15$, $p = .32$, $\eta^2 = .16$, no effect of condition, $F(1,6) < 1$, and no interaction between status and condition, $F(1,6) < 1$. Between the Ger-Plym and Ger-Ger conditions, there was no effect of status, $F(1,6) < 1$, no effect of condition, $F(1,6) < 1$, and no interaction between status and condition, $F(1,6) < 1$.

Discussion of Experiment 13

The results of Experiment 13 further support the findings of Experiment 12, that infants at 10 months are not able to segment speech when an unfamiliar foreign accent is present. These results also concur with the findings of Schmale and Seidl (2009), according to whom infants are not able to segment continuous speech when at least one foreign accented speaker is present. As for Experiment 12, a close inspection of Figure 37 reveals actually the same pattern of results, namely that the most difficult condition appeared to be the German-Plymouth condition (it was the Scottish-Plymouth condition in Experiment 12). It seems logical that this situation would be the most difficult one: not only are the children presented with a whole range of new supra-segmental and segmental information during passage habituation, but also they have to normalise accent-related information to identify the extracted words in the test phase. In comparison, the Plymouth-German condition only necessitates normalising segmental information across accents, and the German-German condition only requires infants to do acoustic matching while processing new prosodic and segmental information.

Chapter 8

Discussion of developmental studies

The aim of this section was to investigate what infants are learning about different accents in speech. Experiment 8 examined whether five month old infants were able to discriminate their own dialect (South West accented English) from another, unfamiliar regional dialect (Welsh accented English). Using a habituation/dishabituation task, infants were presented with an alternation of both dialects, and looking times were analysed to ascertain whether the infants were able to differentiate between them. It was found that infants looked significantly longer to the habituated accent over the non-habituated accent, regardless of which accent was presented as the habituated accent. Therefore, these results demonstrated that, by five months, infants had learnt to discriminate between two regional accents.

What was not clear from Experiment 8 was whether infants had developed a general discrimination ability for dialects in their native language, or whether they had learnt something specific about their own dialect that allowed them to discriminate it from others. Experiment 9 was designed to investigate this by presenting five month old infants from the South West of England with two unfamiliar regional accents (Welsh and Scottish accented English), using the same habituation method as Experiment 8. The results of this experiment were not significant, meaning that at five months, infants were not able to discriminate between two dialects that they were unfamiliar with. This suggests that infants had learnt something specific about their own dialect which allowed them to discriminate it from others.

Experiment 10 was then designed to see whether discrimination abilities evident at five months were still present at seven months. This was due to evidence in the literature suggesting that perhaps infants "lose" this ability between six and eight months (Kitamura et al., 2006a, 2006b; Phan and Houston, 2006). Therefore Experiment 8 (using South West and Welsh accented English) was replicated with seven month olds. However, in contrast to previous findings, it was demonstrated that infants at seven months were still able to discriminate between their own and an unfamiliar regional accent.

In order to investigate the possibility that foreign accents may recruit different processing mechanisms than regional accents (Floccia et al., 2006; 2009a; Girard et al., 2008), Experiment 11 was designed to see whether infants at seven months could discriminate their own dialect from a foreign (French) accent. Surprisingly, it was found that infants at seven months were not able to discriminate a foreign accent from their own, even though they were able to perform the discrimination between their own and a regional accent at seven months.

Firstly, this study's findings suggest that infants at five month are only able to discriminate between dialectal variations of their own language only when their own dialect is present. This would seem to fit with previous studies that suggest that infants at five months can only discriminate between two different languages from their native rhythmic class only when their own, or dialectal variation of their own language, is present (Nazzi et al., 2000). However, the findings also seem to contrast with Nazzi et al.'s results. In their study, it is worth noticing that infants could contrast a dialectal variation of their own language with another language from the same rhythmic class, that is, American infants were able to discriminate British English from Dutch. This would suggest that the American infants recognised British English as similar to their dialect, as if they classified them as the same, rather than different dialects. It would follow from this that, if infants represent dialectal variations of their language as similar, then they would not discriminate between two dialectal variations, regardless of whether their own dialect was present. In this study it was found that infants can in fact perform this discrimination, which suggests that infants are able to recognise and ignore dialectal variations dependent upon the task, even at five months.

Similarly, the findings are consistent with those of Nazzi et al.'s (2000), that at five months infants are able to discriminate between their own and another dialectal variation of their own language. Interestingly, the infants in Nazzi et al.'s study demonstrated longer looking times to the non-habituated, rather than habituated accent, whereas the infants in our study demonstrated the opposite effect. As discussed earlier, this could be attributed to the salience of our stimuli compared with Nazzi et al.'s, and in fact this familiarity effect was observed to be reversed in our seven month olds, with a novelty effect now evident.

Another interesting aspect was the discrimination for regional accents shown at seven months. This does not fit in with other studies (Kitamura et al., 2006a, 2006b; Phan and Houston, 2006), which suggest that this discrimination ability disappears between six and eight months. The reason for this discrepancy may be due to differences in methodologies. As previously discussed, the discrimination task used in this study could have been more sensitive to the preference procedure used in studies such as that by Kitamura et al. (2006a). In addition, Kitamura et al used repetitions of the same sentence, which may have had the effect of biasing the infants towards focusing on the phonetic similarity between repeating sentences, whereas, in contrast, this study used passages made up of complex sentences with words presumably unknown to the infants. By using this more complex and variable structure, the stimuli could have had the effect of emphasising within-category similarity, that they were produced by speakers with the same accent. Whatever the reasons for the discrepancies between my findings and previous findings, it seems that infants do not perhaps "lose" their discrimination abilities that were previously evident, rather that this ability only becomes evident dependent upon the demands of the task.

One of the surprising findings of this study was that, although there was evidence of discrimination at seven months between their own accent and a regional accent, there was no evidence of discrimination between their own accent and a foreign accent.

Many observations point to the fact that foreign accent should be easier to discriminate than a regional accent, because for example they are characterised by more inter- and intra-speaker variability regarding segmental and supra-segmental features. In addition, it has been shown that at five years for French children, and at seven years for British children, children are better at recognising a foreign accent rather than a regional accent (Floccia et al., 2009a; Girard et al., 2008), showing that in general it is perceptually more salient than a dialect. However, those same studies reported that British children at five years did not distinguish regional or foreign accents from their own accent, suggesting perhaps that the perceptual asymmetry between foreign accents and regional ones is developing through language exposure. As discussed, a possible explanation for this discrepancy at seven months could be that infants at that age are more focused on the supra-segmental properties of speech, and as such would be able to detect a change between two dialects characterised by different intonational systems (as was evident between Plymouth and Welsh accented English in Experiment 10), provided that their native dialect is present. Therefore, perhaps the reason the infants fail to discriminate French accented speech is because the French speakers used in this study were by this stage very experienced English speakers (albeit with an accent), and as such had a good knowledge of the intonation systems of the South West accent. Perhaps, after seven months infants focus shifts, for example to engage in the processing of segmental information, and so perhaps their ability to discriminate accents declines until seven years, when they have been shown to be able to discriminate successfully using accent related information.

With the results pointing towards the acquisition of dialect-specific intonation information in early infancy, what could be the advantages of such a strategy? One such advantage could rest in the way the intonation system defines where prominence is to be found in phonological phrases, which can be dialect-specific (e.g. Grabe, 2004). It has been proposed that prominence location guides infants during the bootstrapping of syntactic acquisition by indicating whether their language is head-final or head-initial (Christophe, Nespor, Guasti & Van Ooyen, 2003). These authors showed that two to three month old infants could distinguish between head-initial French sentences and Turkish head-final sentences even when the stimuli had been manipulated to remove all phonemic information leaving only prosodic information. Infants' learning of the fine-grained dialect-specific prosodic features of their native language reveals how fundamental prosody is in the acquisition of language (see Höhle, 2009, for a review of the role of prosody in early acquisitions).

The indication that five month old infants have acquired dialect-specific intonation patterns of their native language also lend credence to the recent hypothesis of Nazzi (submitted) which suggests that within-language differences might affect the course of language development. This was built around a series of studies which examined how Canadian-French and Parisian-French learning infants develop word segmentation abilities skills (Polka et al., 2008; Nazzi et al., 2008; see also Polka and Sundara, 2003; Nazzi et al., 2006), based upon the seminal report by Jusczyk and Aslin (1995) showing that seven and a half month old American infants could retrieve new word forms from passages containing (or not) those words. Using this technique (which was also used in Experiment 12 and 13), it was found that a slight advantage was revealed in disyllabic word retrieval for the Canadian-French over the Parisian-French eight month old infants. Specifically, whilst Canadian-French learning children were able to recognise these types of target words within carrier passages when the word was presented before the passage, the Parisian-French learners could not. The latter group of infants only succeeded in the task if the passages were presented first as habituation, and then followed by the isolated words (passage-word paradigm). Nazzi (submitted) suggested that this could be due to Parisian infants needing more time to process the passages than Canadian children, a consequence of the larger intonation variations in Canadian than Parisian French (Ménard et al., 1999) providing more cues for word segmentation.

However, if children need to specify the intonation system they are exposed to in order to retrieve syntactic-related information or segment words, they also need to normalise the incoming inputs so that speech produced in an unfamiliar accent would be understood. Until recently, little was known about children's abilities to normalise the speech signal against indexical accent-related variations. Recent evidence suggests that infants develop the ability to adapt to an incoming unfamiliar accent, instead of having the ability to normalise any incoming variability from the onset of language acquisition. Best, Tyler, Kitamura, Notley and Bundgaard-Nielsen (2008) tested 14 and 19 month old Australian toddlers in two preference tasks for Australian English and Jamaican English during the presentation of lists of familiar versus unfamiliar words. Their results showed that the recognition of familiar words presented in the unfamiliar accent were primed if they were presented in their home accent first at both ages. However, when Jamaican English accented words were presented first this disrupted subsequent recognition of familiar words presented in the Australian English accent with the younger group of toddlers. This suggests that maturation and/or further exposure to the maternal language results in an increasing ability to retrieve phonological information under variable phonetic information (see also Mulak, Best, Irwin and Tyler, 2008).

Similarly, Schmale and Seidl (2009) carried out a series of word segmentation studies comparing American English and Spanish accents using the same kind of task as Jusczyk and Aslin (1995) with American infants. At nine months of age infants failed to recognise habituated words if two different foreign speakers were used to produce the habituation and test stimuli, whilst at 13 months habituation was successful. This suggests that at nine months of age infants' knowledge of foreign accented speech was not sufficient to allow them to normalise and recognise a familiar word when produced in that accent.

Experiments 12 and 13 echo and extend the results of Schmale and Seidl (2009), by testing 10 month olds in a word segmentation task, which contrasted the home dialect and an unfamiliar (Scottish) dialect (Experiment 12), and a foreign accent (German) and the home dialect (Experiment 13). Although the results were not statistically robust due to a small sample size, the pattern of results in the two experiments are similar; infants only looked longer at the target words when both speakers were from the same accent background as the infant. When the unfamiliar regional dialect or the foreign accent was present for either the passages or the words (or both), the infants did not seem to be able to successfully segment the target words.

Schmale and Seidl used a slightly different method to the studies reported here, where they presented infants with the target words first, and then looked for evidence of segmentation from the passages, whereas my experiments presented the infants with the passages first and then looked to see if the infants were able to recognise target words from these passages. The implication of these different methods is that perhaps the task demands of my experiments were more difficult than those of Schmale and Seidl's technique. By presenting infants with the target words first, this would have allowed the infants to simply encode segmental information related to these words (i.e. what the beginning and the end of the word sound like), and then the infants would only need to recognise these two sounds together in continuous speech in order to recognise the target words. In contrast, presenting infants with the passages first meant that the infants were provided all the segmental and supra segmental information first, and they were expected to be able to process all of this information, and then be able to successfully recognise one of the words presented within the passages when it was presented in isolation. Although the infants in these studies were shown to be able to perform this task when presented with passages and words in their own accent, this was perhaps too difficult for the infants when also faced with the presence of different accents, since children then have to not only process a wide range of linguistic information from the signal, but they also need to normalise this information to compare it with the incoming isolated words. It is possible perhaps that, by utilising Schmale and Seidl's method, evidence of segmentation of continuous speech when an unfamiliar regional accent was present would be shown.

So how do children learn to normalise accent-related variations? Whilst there is little research that addresses this area, some studies have examined how infants achieve phonetic discrimination in the presence of orthogonal variation, such as the emotion (Singh et al., 2004; Singh, 2008) or inter-speaker differences (e. g. Jusczyk et al., 1992; Rost and McMurray, 2009). Using an HAS procedure with an immediate or two min delayed stimulus change after the habituation criterion, Jusczyk et al. (1992) found that multiple speakers were detrimental to two month-olds' discrimination of /bug/ versus /dug/, especially in the 2-min delay condition. In a similar vein, at seven and a half months of age, infants could recognise familiarised target words in examples of speech across different speakers only when the speakers are of the same gender, with cross-gender familiarisation only occurring at 10.5 months (Houston and Jusczyk, 2000). Whilst these studies suggest that phonetic representations can be hindered by orthogonal speaker variation during the first six months of acquisition, in older children the adjunction of variability can be beneficial to the consolidation of phonological categories. In the seminal report by Stager and Werker (1997), 14 month old children failed to learn new words like /bih/ and /dih/ in the Switch task (which associates presentation of pictures and labelling). Rost and McMurray (2009) hypothesised that children needed more variability in the speech stimuli in order to extract and build a robust phonological representation of the two stimuli. They replicated the study by presenting 36 tokens of each of the to-be-learned items, produced by 18 different speakers. In these conditions the children showed evidence of word learning, suggesting that maturation and/or repeated exposure to language variability can not only develop the ability to use indexical variability in order to achieve stable phonological representations but also consolidate phonological categories (see also Floccia et al., 2000; Singh, 2008). With that perspective, exposure to multiple or unfamiliar accents could perhaps benefit infants' language development, as it provides them with additional variability to help them extract invariant phonological information. If valid then children raised in multidialectal environments (with mother and father speaker with different dialects for example) could acquire phonological categories earlier than those raised in a monodialectal environment. Further research into the influence of language variety exposure onto perceptual abilities would be needed to answer this empirical question.

To sum up, it was found that infants between five and seven months are able to discriminate their native regional accent from another unfamiliar one. This demonstration adds to the existing knowledge that the onset of language learning is characterised by the important role played by prosodic information. Repeated exposure should allow the progressive abstraction of phonological representations across orthogonal indexical (accent-related) information, possibly thanks to the computation of covariates between different phonemic or prosodic cues (Singh, 2008), or because of sensitivity to the statistical distributions of sounds in their native language (Maye, Weiss an Aslin, 2007). It is hoped that further investigations into the perception of within-language variations, such as this study, will extend our knowledge of the processes by which the robust, abstract-entries systems of lexical representations found in adults can be developed (Pallier et al., 2001).

Finally, this study would like to end on a comparison between the development of perception for accents as compared with other kinds of indexical variability, such as talker identity or emotions. It seems that the route taken to achieve normalisation may differ for accent-related information compared with other forms of variability. This can be seen in the fact that infants can cope with variability such as talker identity and affect at 10.5 months (Houston and Jusczyk, 2000, Singh et al., 2004) but accent related impairments are still evident at 10 months (infant Experiments 12 and 13), and it is not until 13 months that infants seem to be able to cope with accent related variability (Schmale and Seidl, 2009). Perhaps this can be attributed to the differences between accent-related variation and other sources of variability: accents modify speech at the phonological level, in a discrete way, whereas talker identity and speech rate modify speech continuously and acoustically. In the course of developing a fully mature language comprehension system, it seems reasonable to suppose that the lowest levels of speech processing (acoustic and phonetics) would be built up before more abstract and language-specific ones such as phonological representations.

Chapter 9

General Discussion

One central question in psycholinguistics has always been to define the relationships between speech production and perception, that is, to determine to which extent both processes functionally rely on the same mechanisms and memory systems (see for example Levelt, 1999). Regarding phonology and prosody, one common observation is that as adults, we are not very flexible when it comes to speech production. When learning a new language we tend to produce this in a foreign accent (Flege, 1981). We also tend to retain our native dialect and find it very hard to modify it , although in the long term our speech may become similar to that of a larger community we live in (e.g. Gallois and Callan, 1988; Sancier and Fowler, 1997). Decades of research have demonstrated that this lack of flexibility seems to be observed in perception as well: for example prelexical encoding has been shown to be highly language-dependent, with native speakers of rhythmic languages such as French and Spanish relying on the syllable (Mehler, Dommergues, Frauenfelder & Segui, 1981; Sebastian-Galles, Dupoux, Segui and Mehler, 1992) and speakers of stressed languages such as English and Dutch being more sensitive to stressed syllables (Cutler, Mehler, Norris & Segui, 1986; Zwiterserlood, Schriefers, Lahirir and Van Donselaar, 1993).

Another example stems from recent research by Dupoux, Sebastian-Galles, Navarrete and Peperkamp (2008) showing that adult French listeners show a perceptual stress 'deafness', that is, the inability to encode stress contrast information in syllables to perform lexical access or discrimination tasks. This is caused by the fact that in the French language stress is fixed and is not used contrastively at the lexical level. As a consequence, French-learning infants show no spontaneous attention to stress information in speech sequences from as early as nine months, on the contrary to Spanish learning infants whose language uses stress contrastively (Skoruppa, Pons, Christophe, Boshe, Dupoux, Sebastian-Galles, Limissuri and Peperkamp, 2008).

These examples illustrate the fact that speech perception in adulthood is highly constrained by the phonological rules of our native language.

This constraint is such that we are not only constrained by the language we have learned as a child, but also by the dialect we have been raised in. We are capable of adaptation to other accents or dialects in the long-term, but in the short term, we constantly need to adjust to them. Taken together, my studies and those before (e.g. Adank and McQueen, 2007; Floccia et al., 2006) indicate that this adjustment is achieved at the prelexical level and not at the lexical level, as in our lexicon we have stored single canonical abstract representations of words. Sumner and Samuel (2009) looked at priming of rhotic (allowing an "r" after a vowel) and non-rhotic forms of words with different American populations, those who have a rhotic dialect (the most prominent in the US) and those who do not. They found that whereas both forms can be processed equally well by the two populations, that is, they can prime related words as efficiently, only one form is retained in long-term memory. Similarly to the findings of Sumner and Samuel, Dufour, N'Guyen and Frauenfelder (2007) found a comparable effect in French speakers. They investigated the perception of /e/ - /ɛ/ and /o/ - /ɔ/ contrasts, which are both produced in standard French, but only the latter one is produced in Southern French. Using a lexical decision task, they were able to show that native speakers from the South of France showed an effect of repetition priming for the /e/ - /ɛ/ contrast, whereas Standard French speakers did not. These findings suggest that Southern French speakers perceive this contrast as phonemically identical and as such treat them as homophones whereas Standard French speakers perceive them as different (see also Brunelliere, Dufour, N'Guyen and Frauenfelder, 2009).

These studies suggest that adults' lexical entries are built around dialect-specific representations, which is also a conclusion reached in my own studies. Indeed observation of an initial lexical processing impairment when presented with an unfamiliar dialect was replicated (Experiments 1 to 4, and 5 to 7 in the immediate condition), suggesting that deviations from the "home standard" productions necessitates some extra processing. Most importantly, it was also shown that this initial impairment diminishes in delayed response condition when using words (Experiments 5 and 6) instead of non-words (Experiment 7), suggesting that stored lexical representations do not contain dialect-specific information, and that this information can be discarded from working memory by top-down lexical activation.

However, in the long-term, we are able to adapt to accents, as demonstrated for example by familiarity effects found in this study and decrease of accent-related processing impairment with repeated exposure (Adank and McQueen, 2009; Adank et al., 2007; Floccia et al., 2006; Maye et al., 2009), which triggers interesting questions about the nature of the entire normalisation process.

Capitalising on the idea that lexical representations are uniquely dialect-specific (perhaps not over a life time though, see Brunelliere et al., 2009), and further to the study by Norris et al. (2003), this study has attempted to develop a model which explains how accent-related information is dealt with in the course of lexical processing. The prelexical representation issued from an incoming speech signal is compared with existing lexical entries, and if no match is found, or only a weak one, the lexicon triggers the use of an accent filter. This accent filter's role is to modify prelexical processing using existing accent templates stored in long-term memory. If no filter is efficient enough, then a new template is built up and encoded that can be retrieved for further use. One important step in this model which I would like to discuss here is its first stage: the process that leads the lexicon to send a training signal to prelexical processing. Lexical recognition in adults benefits enormously from top-down information which allows the listener to correctly guess the identity of words in case of inadequate or uncertain bottom-up information (e.g. Connine and Clifton, 1987; McClelland and Elman, 1986; Samuel,1997).

This ability is crucial when encountering accented speech that we do not have previous experience of. Top-down influences can be of two kinds: semantic contextual information which can help us to identify unclear content words, but also metalinguistic awareness, which can assist us in appreciating the acoustic quality of speech. Thanks to this ability we can identify the social and geographical origins of the listeners, which can be of help to adjust the contextual framework of the incoming speech. Awareness for dialects is growing with maturation and repeated exposure to variable speech, as showed by increasing dialect categorisation abilities between five and seven years of age (e.g. Girard et al., 2008; Floccia et al., 2009a).

Another interesting aspect of this model is its development through childhood. It is well established that humans go through a critical period for language acquisition which extends from birth to early puberty presumably (e.g. Johnson and Newport, 1989), during which children are very flexible in terms of speech production and perception. During this period, typically-developing children show that they are capable of mastering the phonological and prosodic rules of their maternal language perfectly, and that this can apply to the learning of a second language (e.g. Pallier, Dehaene, Poline, LeBihan, Argenti & Dupoux, 2003).

They also have the ability to acquire new dialects when moved from one region to another, with proficiency generally inversely related to age. For example, Trudgill (1986) found that seven year old twins had both acquired Australian vowels within six months of their arrival from the UK, even though they displayed different patterns of acquisition. Similarly, Chambers (1992) examined accent production in six 7 to 15 year old Canadian English-speaking youngsters when moved to southern England. He found that all the children acquired new dialectal features, although the younger children were more likely to acquire the more complex phonological features than their older siblings. Payne (1980) also found that older American adolescents acquired a

Philadelphian accent after moving to that area, but could not acquire more complex phonological rules.

Therefore, a naïve idea would be to assume that children's abilities to perceive new accent variants are very important in infancy and childhood, with changes occurring with puberty to explain the lack of learning plasticity observed in adults. However the story is not so simple. First as adults we are rather good in perceiving differences between dialects (e.g. Clopper and Pisoni, 2004), we can detect them with a high degree of certainty if not identify them correctly. Some of us (comedians, actors) are even excellent in imitating them showing that they not only have a perfect perceptual accent template for a particular accent, but also that they can use it to constrain phonological processing in production. However by default we stick to the dialect we have learned in childhood. In other words, we have excellent metalinguistic abilities, but very poor (automatic) phonological plasticity. In contrast, young infants lack metalinguistic abilities, but display excellent phonological plasticity, as evidenced by their abilities to learn their maternal language, acquire a second one or change dialects in way far more efficient than adults. However, during the first year of life research indicate that infants' perceptual abilities for processing speech sounds get more and more constrained by the language they learn. They start by focusing on their native language, and native dialect (Nazzi et al., 2000; Kitamura et al., 2006a, 2006b; Diehl et al., 2006; Infant Experiment 8, this study). From this, they then learn the vowels and consonants of their native language, and this, quite often, occurs with a loss of sensitivity for non-native contrasts (Werker and Tees, 1984; Best and McRoberts, 2003; Best, McRoberts, LaFleur, and Silver-Isenstadt, 1995; Kuhl, Stevens, Hayashi, Deguchi, Kiritani and Iverson, 2006).

This language-specialisation of speech perception occurs at a time in life during which children have presumably not developed yet any metalinguistic awareness, and perhaps no significant top-down influences from the lexicon. Indeed, although their receptive vocabulary grows regularly from six months onward (Tincoff and Juscczyk, 1999), it only contains on average 23 words at eight months, and 75 at 12 months (taken from the perhaps optimistic American study by Fenson, Dale, Reznick, Bates, Thal & Pethick, 1994), which means that recognition facilitation brought by these familiar items can only benefit a small proportion of everyday encountered words. The point is that between six months and 12 months, infants reach a high level of phonological specificity, with a poor level of metalinguistic abilities and little top-down lexical activations. However, at the same time, children need to develop the ability to normalise speech across variations, otherwise they will be unable to process speech when presented with variants, which we know is not the case later in life. The present study as well as those by Schmale and Seidl (2009) and Phan and Houston (2006) suggest that normalisation abilities for dialects or accents are not available yet at 10 months. Perhaps normalising accent related variants begins when infants start linking sounds and meaning, which does not occur until the end of the first year, and becomes very active during the second year (see Saffran and Estes, 2006, for an excellent discussion). Increasing top-down activation and semantic contextual information could then help them to use or develop their normalisation abilities, and accept many dialectal variants as corresponding to familiar words (Best, Tyler, Gooding, Orlando and Quann, 2009). From the onset of the second year, some researchers have indeed argued that infants start to develop an adult-like lexicon with similar activation and inhibition mechanisms (Swingley and Aslin, 2002; Werker, Fennell, Corcoran and Stager, 2002; Werker and Fennell, 2004; see however Walley, 1993; Charles-Luce and Luce, 1990). From then on, perhaps their ability to detect dialectal differences diminishes (or their normalisation capacities increase) not because they are unable to discriminate between dialects anymore, but rather because dialect-related variations do not appear as important any more, as compared with the meaning carried by speech. This could be because young children lack metalinguistic abilities, which would help them to switch their attention from the meaning of utterances to the sounds they are made of. Another possibility – not exclusive - to explain why normalisation abilities for accents mature during the second year onwards is related to the resourceconsuming process of linking sound and meaning (e.g. Stager and Werker, 1997; Werker et al., 2002). Indeed when having to consider both the phonetic representations of newly encountered words and their meaning, toddlers have been shown to be unable to encode fine-grained phonetic information; this would explain why they would appear to normalise dialect-related variations. They would show normalisation of accented speech not because they have acquired specialised accent filters, but because the cognitive load associated with the linkage of speech to meaning would prevent them from processing minor differences in the input. At 10 months however, children would pay greater attention to sounds because they wouldn't compute any meaning at that stage, therefore any differences between speech sounds would be perceived as relevant. This would explain why they would be unable to successfully segment words from accented continuous speech, because they would process every kind of phonetic and phonological differences and treat them as relevant in the task (Infant Experiment 12 in this study).

The studies reported in this thesis demonstrate our abilities in processing accented related variations in infancy and in adulthood. Infants begin by focusing on the differences between speakers (such as gender, accent, etc.) but toward the end of the first year, and into the second, their focus shifts from the differences to the similarities, at a stage when they begin to focus on the meaning of the sounds. It is important for infants to learn to process accents and to essentially ignore them so that speech can be understood, as this ability becomes vital during later life in order to understand speakers from different backgrounds to ourselves. This ability is shown by the adult participants' recognising words when produced in a foreign accent, rather than classifying them as pseudo words, as this would not be possible if infants had not learnt to process accented speech at an early age. In order to be able to deal with these variations, infants must first learn to recognise the accent in order to process, and this is shown by infant's abilities to discriminate their own accent from other regional variations at an early age.

Overall, the studies described in this thesis have added to the literature related to the perception and processing of accent related indexical information in childhood and adulthood. The adult studies have added to previous models of word recognition by attempting to explain the normalisation process that occurs before lexical access can take place, and has also contributed to the debate between abstract entries and exemplar based models of lexical representations, providing support for abstract lexical representations in the lexicon. The findings with infants have extended our knowledge of what infants are learning about their own and other regional and foreign variations of their maternal language between 5 and 10 months of age, where they have learnt to recognise their own accent from others, before they begin to deal to ignore irrelevant variations in speech, such as accents.

In conclusion, this thesis hopes to have contributed in this work to the growing body of knowledge aiming at explaining how humans acquire the ability to process continuous speech in variable situations, an ability that no automatic speech recognition software has managed to mimic so far. It has emphasized the role of growing top-down influences in the development of normalisation abilities, through increasing lexical knowledge and metalinguistic abilities. These two sources of information will contribute to help the child sort out the "blooming, buzzing confusion" (James, 1890) that must be dialect variability around its self, and produce a robust adult speech recognition system that can, at the same time, perceive dialectal or accent-related differences, and ignore them.

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Appendix A: Adult Experiments Stimuli

Adult Experiment 1 (session 1), Experiment 2, Experiment 3 and Experiment 4 stimuli

Training

I wish I would have more time to play in the bedroom

My father thinks that John should try to search his pockets

Mum and Dad are very proud of their brand new blanket

For my birthday Sophie has decided to offer me some pictures

It was last year when I first heard about the leacher

If Dad agrees I will go shopping to get some ravement

Yesterday the doctor said I have to eat a lot of gaskyles

His grandmother is famous for her garden full of tonnets

Block 1 (Baseline)

Alexander likes to run as fast as he can when he sees a dolphin

Alison always insists on having the biggest of all the puppets

Angelina is sad because she can't see all the bubbles

Barbara doesn't want children to get close to her garage

Because she forgot her classes Michelle couldn't see all the beautiful badgers

Caroline collects all the small boxes to keep her little candles

Dad doesn't want me to use all the buttons on the castle

Elizabeth doesn't understand why she can't touch all the buckets

Eric shouted very loud when he saw that we had broken all the presents

Everyday my Dad and brothers enjoy eating their butter

You can't sort out all these pictures because they all have different gamlets

Yesterday Arthur didn't want to put anything new in his dopic

When we are at school the teacher often tells us about coclones

When they are at home children are allowed to play with the barlot

What I prefer when I'm on holiday is to collect all the dopels

Block 2 (Foreign accent)

I like going to the pub because I like getting battles

I can't wait to go home because I miss my glacier

Jack and Jill were very happy when they were allowed to catch the beetle

He was late getting home because he ate the last toffees

Because he had kept his room clean Fred got a new garment

Junior tried hard but he could not fit into the tunnel

After a night out Nick really liked to eat some turnips

Just for a change Sally wants to try a different cotton

My Dad said that if I was good I would get a canon

I wish I would find the courage to talk to the new bishop

For a short moment Barnaby thought that he saw prixal

He was tired but he still had to find the missing dexton

He tried not to but he couldn't help looking at the gundeg

The road was closed because there had been a recent bahal

When it is raining my cat does not like to see the tavorn

<u>Adult Experiment 1 (session 2) stimuli</u>

Block 1 (Baseline)

Last Christmas Samuel and Derek managed to catch a tiger

Madeline went with her grandfather to the shop to buy some towels

Mandy always comes to visit me so that we can play with my kitten

Mark fell when he was trying to avoid walking on a bottle

Mary returned to her grandparents to see all the parcels

Mum doesn't understand why my brother refuses to drink any coffee

Mum punished all the children who refused to eat the pasta

My mother really didn't like us playing with the new basket

Nicholas is disappointed because he didn't manage to find his donkey

Rebecca was very sad when she was told she couldn't use the basin

The new teacher told us last Wednesday that she liked the gieder

She would like to go shopping so she could get us some busner

Samantha knew that it was Leon who had taken all her billers

Once again Phillip and Lucile forgot that they had to get some doover

No-one wants to play with Timothy because he never lets us have his new proson

Block 2 (French)

Michael looked down and saw the floor was made of granite

She chewed carefully and thought she tasted some garlic

John could not remember when he had last seen his doctor

At the zoo the little boy cried because he was scared of the turkey

Sarah looked more closely and saw that it was some people

He ran very fast but he was too slow to catch the camel

My granny saw small bits and thought that it was the cocoa

In the morning Karen likes to play with all her buttons

When he had gone his grandparents went back to the country

One day last week the sun was shining bright over the temple

When he eventually ran out of pens he had to use disbus

The dog was barking because he wanted to chase the pulker

At the end of the film the hero was very kogla

While reading a book Peter heard a noise at the burror

I went on holiday last year and found a great poober

Block 3 (Baseline)

Seren would like Father Xmas to bring her a brand new carpet

Stephanie always hesitated to say that she wanted to buy some curtains

Her mother would like Rosemarie to be very careful with the pumpkin

Toni has made a gorgeous little box to collect all her papers

Victoria gets closer to the stage so that she can see the party

When he was a child Rodney used to like playing with his parrot

When it's cold outside my brother enjoys a nice cuddle

While she was in town Catherine insisted to have a picnic

Yasmine doesn't want to go and see what stands next to her garden

With her magic wand the witch changed all the children into babies

My grandmother always says that we should buy more carwer

Margaret and Mum did everything they could to move your red pindon

Louis would like that he wouldn't cry each time he sees some danay

Julian doesn't know where his Dad has hidden all the badbles

Tonight Jeremy wants his brothers to put away the little togger

Block 4 (Malaysian)

The kids were crying because the teacher took away their ticket

My mum says if you want to be healthy you should eat all your bacon

The fire had gone strong so she could not touch a piece of carbon

Phil had not been paid so he could not buy a new cottage

She stayed with him all day so she could make him pastry

Bill didn't do his homework because he was playing with his crystal

As she came out of the clothes shop she walked on a garbage

After a while she heard a noise and tried to hide her diamond

As it was a nice day they all decided to go out for a ballet

Because he had been naughty he wasn't given any dollars

They were excited because they were going to see the poslin

There was a lot of broken glass so they were careful not to touch their gimcet

At Christmas they would all sit down together to talk about their tarson

He tried to say something but he was stopped by a bonad

At night Kate and Mark liked to stay up and watch the cokrad

Adult Experiment 5 stimuli

	Heard	Seen
Training		
	She won't let him have her toys because he took all her doughnuts	bandage
	Dad was very upset with Ann because she lost her new bandage	cookies
	Sophie was so happy that she said she would give her a nice drawing	doughnuts
	William preferred to exchange his toys so that he could have some nice cookies	drawing
	For my birthday Sophie has decided to offer me some pictures	pictures
	My father thinks that John should try to search his pockets	pocket
	I wish I would have more time to play in the bedroom	bedroom
	Mum and Dad are very proud of their brand new blanket	blanket
Plymouth speaker 1		
	Elizabeth doesn't understand why she can't touch all the buckets	buckle
	Every day my Dad and brothers enjoy eating their butter	bumper
	Caroline collects all the small boxes to keep her little candles	cancel
	Dad doesn't want me to use all the buttons on the castle	cashew
	Eric shouted very loud when he saw that we had broken all the presents	predicts
	Because she forgot her glasses Michelle couldn't see all the beautiful badgers	badgers
	Angelina is sad because she can't see all the bubbles	bubbles
	Alexander likes to run as fast as he can when he sees a dolphin	dolphin
	Barbara doesn't want children to get close to her garage	garage
	Alison always insists on having the biggest of all the puppets	puppets
Plymouth speaker 2		
	With her magic wand the witch changed all the children into babies	baddies
	When it's cold outside my brother enjoys a nice cuddle	casket

Yasmine doesn't want to go and see what stands next to her garden	gargles
When he was a child Rodney used to like playing with his parrot	paddle
While she was in town Catherine insisted to have a picnic	pancake
Seren would like Father Xmas to bring her a brand new carpet	carpet
Stephanie always hesitated to say that she wanted to buy some curtains	curtains
Toni has made a gorgeous little box to collect all her papers	papers
Victoria gets closer to the stage so that she can see the party	party
Her mother would like Rosemarie to be very careful with the pumpkin	pumpkin

Irish speaker 1

Karen will help you to go there to collect all the pillows	pickle
Last month my dream finally came true when I had a new table	tassle
Jessica broke the chair when she went up in the tractor	tracksuit
In the afternoon John and Mary enjoyed finishing their tea with a trifle	triple
In the evening Virgil and Thomas usually complain about their tummy	tumble
Every day this month Matthew refused to eat his breakfast	breakfast
Hannah is still searching for the bag she wants to give to her brother	brother
He always preferred playing with his car rather than with the dragon	dragon
Everything was so mixed up that you couldn't find your pencil	pencil
Fanny still hasn't succeeded in selling her nicest tortoise	tortoise

Irish speaker 2

Nicholas is disappointed because he didn't manage to find his donkey	baboon
My mother really didn't like us playing with the new basket	basement
Rebecca was very sad when she was told she couldn't use the basin	basic
Mum doesn't understand why my brother refuses to drink any coffee	cobble
Mum punished all the children who refused to eat the pasta	pasty
Mark fell when he was trying to avoid walking on a bottle	bottle
Mandy always comes to visit me so that we can play with my kitten	kitten

Mary returned to her grandparents to see all the parcels	parcels
Last Xmas Samuel and Derek managed to catch a tiger	tiger
Madeleine went with her grandfather to the shop to buy some towels	towels

French speaker 1

When in the new bookshop Stacey and John buy lots of colours	canine
I really like growing up because I can go to college	collar
When I was abroad I saw a man fall over in a desert	design
When Dad came here he always wanted to watch the tennis	tenant
Following such remarks Ralph would always wear a turban	turbo
After lunch Gareth liked to play with his brand new barrier	barrier
Mum was angry because the dog ran into the canyon	canyon
As friends Helen and Sophie liked to talk with the new dentist	dentist
On the way to the shopping centre she heard a gospel	gospel
When he had finished Chris cleaned his cup with the powder	powder

French speaker 2

In the morning Karen likes to play with all her buttons	baton
He ran very fast but he was too slow to catch the camel	cabin
My granny saw small bits and thought that it was the cocoa	cassette
When he had gone his grandparents went back to the country	coughing
One day last week the sun was shining bright over the temple	turtle
John could not remember where he had last seen his doctor	doctor
She chewed carefully and thought she tasted some garlic	garlic
Michael looked down and saw the floor was made of granite	granite
Sarah looked more closely and saw that it was some people	people
At the zoo the little boy cried because he was scared by the turkey	turkey

Malaysian speaker 1

I wish I would find the courage to talk to the new bishop	biscuit
My Dad said that if I was good I would get a canon	cabbage
Just for a change Sally wants to try a different cotton	coating
Junior tried hard but he could not fit into the tunnel	tender
After a night out Nick really liked to eat some turnips	turgid
I like going to the pub because I like getting battles	battles
Jack and Jill were very happy when they were allowed to catch the beetle	beetle
Because he had kept his room clean Fred got a new garment	garment
I can't wait to go home because I miss my glacier	glacier
He was late getting home because he ate the last toffees	toffees

Malaysian speaker 2

As it was a nice day they all decided to go out for a ballet	babble
Bill didn't do his homework because he was playing with his crystal	crispy
After a while she heard a noise and tried to hide her diamond	diagram
Because he had been naughty he wasn't given any dollars	dollop
As she came out of the clothes shop she walked on a garbage	garlic
My mum says if you want to be healthy you should eat all your bacon	bacon
The fire had gone strong so she could not touch a piece of carbon	carbon
Phil had not been paid so he could not buy a new cottage	cottage
She stayed with him all day so she could make him pastry	pastry
The kids were crying because the teacher took away their ticket	ticket

<u>Adult Experiment 6 stimuli</u>

Training

She won't let him have her toys because he took all her doughnuts	bandage
Dad was very upset with Ann because she lost her new bandage	cookies

Sophie was so happy that she said she would give her a nice drawing	doughnuts
William preferred to exchange his toys so that he could have some nice cookies	drawing
For my birthday Sophie has decided to offer me some pictures	pictures
My father thinks that John should try to search his pockets	pocket
I wish I would have more time to play in the bedroom	bedroom
Mum and Dad are very proud of their brand new blanket	blanket

Plymouth speaker 1

Elizabeth doesn't understand why she can't touch all the buckets	buckle
Every day my Dad and brothers enjoy eating their butter	bumper
Caroline collects all the small boxes to keep her little candles	cancel
Dad doesn't want me to use all the buttons on the castle	cashew
Eric shouted very loud when he saw that we had broken all the presents	predicts
Because she forgot her glasses Michelle couldn't see all the beautiful badgers	badgers
Angelina is sad because she can't see all the bubbles	bubbles
Alexander likes to run as fast as he can when he sees a dolphin	dolphin
Barbara doesn't want children to get close to her garage	garage
Alison always insists on having the biggest of all the puppets	puppets

Plymouth speaker 2

With her magic wand the witch changed all the children into babies	baddies
When it's cold outside my brother enjoys a nice cuddle	casket
Yasmine doesn't want to go and see what stands next to her garden	gargles
When he was a child Rodney used to like playing with his parrot	paddle
While she was in town Catherine insisted to have a picnic	pancake
Seren would like Father Xmas to bring her a brand new carpet	carpet
Stephanie always hesitated to say that she wanted to buy some curtains	curtains

Toni has made a gorgeous little box to collect all her papers	papers
Victoria gets closer to the stage so that she can see the party	party
Her mother would like Rosemarie to be very careful with the pumpkin	pumpkin

Irish speaker 1

Karen will help you to go there to collect all the pillows	pickle
Last month my dream finally came true when I had a new table	tassle
Jessica broke the chair when she went up in the tractor	tracksuit
In the afternoon John and Mary enjoyed finishing their tea with a trifle	triple
In the evening Virgil and Thomas usually complain about their tummy	tumble
Every day this month Matthew refused to eat his breakfast	breakfast
Hannah is still searching for the bag she wants to give to her brother	brother
He always preferred playing with his car rather than with the dragon	dragon
Everything was so mixed up that you couldn't find your pencil	pencil
Fanny still hasn't succeeded in selling her nicest tortoise	tortoise

Irish speaker 2

Nicholas is disappointed because he didn't manage to find his donkey	baboon
My mother really didn't like us playing with the new basket	basement
Rebecca was very sad when she was told she couldn't use the basin	basic
Mum doesn't understand why my brother refuses to drink any coffee	cobble
Mum punished all the children who refused to eat the pasta	pasty
Mark fell when he was trying to avoid walking on a bottle	bottle
Mandy always comes to visit me so that we can play with my kitten	kitten
Mary returned to her grandparents to see all the parcels	parcels
Last Xmas Samuel and Derek managed to catch a tiger	tiger
Madeleine went with her grandfather to the shop to buy some towels	towels

German speaker 1

When in the new bookshop Stacey and John buy lots of colours	canine
I really like growing up because I can go to college	collar
When I was abroad I saw a man fall over in a desert	design
When Dad came here he always wanted to watch the tennis	tenant
Following such remarks Ralph would always wear a turban	turbo
After lunch Gareth liked to play with his brand new barrier	barrier
Mum was angry because the dog ran into the canyon	canyon
As friends Helen and Sophie liked to talk with the new dentist	dentist
On the way to the shopping centre she heard a gospel	gospel
When he had finished Chris cleaned his cup with the powder	powder

German speaker 2

In the morning Karen likes to play with all her buttons	baton
He ran very fast but he was too slow to catch the camel	cabin
My granny saw small bits and thought that it was the cocoa	cassette
When he had gone his grandparents went back to the country	coughing
One day last week the sun was shining bright over the temple	turtle
John could not remember where he had last seen his doctor	doctor
She chewed carefully and thought she tasted some garlic	garlic
Michael looked down and saw the floor was made of granite	granite
Sarah looked more closely and saw that it was some people	people
At the zoo the little boy cried because he was scared by the turkey	turkey

Hungarian speaker 1

I wish I would find the courage to talk to the new bishop	biscuit
My Dad said that if I was good I would get a canon	cabbage
Just for a change Sally wants to try a different cotton	coating
Junior tried hard but he could not fit into the tunnel	tender

After a night out Nick really liked to eat some turnips	turgid
I like going to the pub because I like getting battles	battles
Jack and Jill were very happy when they were allowed to catch the beetle	beetle
Because he had kept his room clean Fred got a new garment	garment
I can't wait to go home because I miss my glacier	glacier
He was late getting home because he ate the last toffees	toffees

Hungarian speaker 2

As it was a nice day they all decided to go out for a ballet	babble
Bill didn't do his homework because he was playing with his crystal	crispy
After a while she heard a noise and tried to hide her diamond	diagram
Because he had been naughty he wasn't given any dollars	dollop
As she came out of the clothes shop she walked on a garbage	garlic
My mum says if you want to be healthy you should eat all your bacon	bacon
The fire had gone strong so she could not touch a piece of carbon	carbon
Phil had not been paid so he could not buy a new cottage	cottage
She stayed with him all day so she could make him pastry	pastry
The kids were crying because the teacher took away their ticket	ticket

<u>Adult Experiment 7 stimuli</u>

Training

Yesterday the doctor said I have to eat a lot of gaskyles	gastrami
Grannie is standing right behind Sophie so she can catch her peaker	pewton
Grandpa always said that he would never allow us to take his tankle	tamek
I don't know who came into my room to steal all my red tifter	tinkle
If Alexis agrees we will all go to the shop to get some cunnel	cunnel
It was last year when I first heard about the leacher	leacher
If dad agrees I will go shopping to get some ravement	ravement

His grandmother is famous for her garden full of tonnets	tonnets

Plymouth speaker 1

The new chef was very good at making the cobbler	corpis
Of all the children, Harry had the quickest deptet	deplune
It was important that they were able to sell their dogmis	dolksy
Matt and Colin were going to play in the pawkey	palcon
Owen was jealous that Ben had been given a better troker	trowfoot
Tommy was late so didn't have time to pick up the dingdeng	dingdeng
George waited all day so he could buy a new glippet	glippet
It wasn't fair for Tony to get the biggest pobin	pobin
He parked his car behind the tall tallast	tallast
It was unusually cold, so she made sure she wore her tosit	tosit

Plymouth speaker 2

All he could think about was when he was going to get his brullcap	brunker
She was worried because she had lost her cultift	culvert
They were both very tired after spending all day in the gibmer	giptide
It was too hot for him to have any gorgog	gordog
In the dark it is very hard to find a kilot	kilotin
In the morning is the best time to see the bellmar	bellmar
They were awake all night listening to the claptrup	claptrup
Ruben wanted to wait before going to buy a dragot	dragot
At night, Finley liked to go out to watch the gigglod	gigglod
All children enjoy a visit from their pimrod	pimrod

Irish speaker 1

Julian doesn't know where his Dad has hidden all the badbles	badlonds
My grandmother always says that we should buy more carwer	carrew

Louis would like that he wouldn't cry each time he sees some danay	daneel
Margaret and Mum did everything they could to move your red pindon	pindred
Tonight Jeremy wants his brothers to put away the little togger	toggle
When they are at home children are allowed to play with the barlot	barlot
When we are at school the teacher often tells us about coclones	coclones
What I prefer when I'm on holiday is to collect all the dopels	dopels
Yesterday Arthur didn't want to put anything new in his dopic	dopic
You can't sort out all these pictures because they all havedifferent gamlets	gamlets

Irish speaker 2

Samantha knew that it was Leon who had taken all her billers	bimers
She would like to go shopping so she could get us some busner	bussem
Once again Philip and Lucile forgot that they had to get some doover	dooghy
The new teacher told us last Wednesday that she liked the gieder	giesel
No-one wants to play with Timothy because he never lets us have his new proson	prolen
They never agreed to learn how to run the big biffin	biffin
This week my sisters and I will go to the big shop to buy a bosler	bosler
Unfortunately Heather has forgotten where she has put all her clavors	clavors
Valerie's grandmother doesn't want to keep all these dakers	dakers
We couldn't put everything in your cupboard because of all theother gipples	gipples

German speaker 1

She liked to travel to experience a different bliffer	blaffold
After her first day Mary really needed to have a chattong	chattul
It was at times like this that Becky was glad to have a cidbit	cidest
Everyone heard the noise that was made by the pogjam	porang
It was quiet so Robin was careful to avoid the tersus	tervert
The bank robber got away with the pretty bellkoy	bellkoy

Megan had an idea but needed to get to the coddlid	coddlid
Mary walked through the shopping centre to find some darson	darson
The young chef tried very hard not to burn the gewter	gewter
Grace thought that she saw someone walking past the tignor	tignor

German speaker 2

Megan was excited because she was finally going to the baggot	baggod
At the office party everyone felt like a drugal	drutal
Julie hated Sunday because she had to eat all her gafker	galkie
He thought that the lady in the shop looked like a toomark	toorman
It is always difficult to find uses for the trimpy	trimson
Jess was very surprised to see the colourful blophy	blophy
Graham was sad because he was going to miss the kunray	kunray
Adam was working hard and forgot to go to the powlick	powlick
For Christmas Ashley hoped he would get a new tinglung	tinglung
Lucy was angry so she wouldn't have any of the treemish	treemish

Hungarian speaker 1

While reading a book Peter heard a noise at the burror	bulep
When he eventually ran out of pens he had to use disbus	divus
At the end of the film the hero was very kogla	kozen
I went on holiday last year and found a great poober	poosen
The dog was barking because he wanted to chase the pulker	pullud
The road was closed because there had been a recent bahal	bahal
He was tired but he still had to find the missing dexton	dexton
He tried not to but he couldn't help looking at the gundeg	gundeg
For a short moment Barnaby thought that he saw prixal	prixal
When it is raining my cat does not like to see the tavorn	tavorn

Hungarian speaker 2

While he was driving home Lewis was stopped by a dingum	dingla
His room was a mess because he did not have room for his kroggy	krocker
The kids playing in the street were making a lot of pigwut	pignal
Before he could go out Bill had to tidy his purwer	purso
Before Sebastian fell asleep he last thought of turile	turrot
He tried to say something but he was stopped by a bonad	bonad
At night Kate and Mark liked to stay up and watch the cokrad	cokrad
There was a lot of broken glass so they were careful not to touch their gimcet	gimcet
They were excited because they were going to see the poslin	poslin
At Christmas they would all sit down together to talk about their tarson	tarson

Appendix B: Infant Experiments stimuli

Infant Experiment 1, Experiment 2, Experiment 3 and Experiment 4 stimuli

Passages used in discrimination task

1A The young boy got up quite early in order to watch the sun rise.
This supermarket had to close due to economic problems.
The committee will meet this afternoon for a special debate.
Having a big car is not something I would recommend in this city.
Mothers usually leave the maternity unit 2 days after giving birth.

1B The next local elections will take place during the winter.
Some more money will be needed to make this project succeed.
Artists have always been attracted by the life in the capital.
Your welcome speech will be delivered without the press offices' agreement.
The latest events have caused an outcry in the international community.

2A The local train left the station more than 5 minutes ago.
The first flowers have bloomed due to the exceptional warmth of March.
Trade unions have lost a lot of their influence during the last 10 years.
The green partys' unexpectedly gained strong support from middle class people.
This is the first time an international exhibition takes place in this town.

2B In this case the easier solution seems to appeal to the court.
The last concert given at the opera was a tremendous success.
They didn't hear the good news until last week on their visit to their friends.
This years' Chinese delegation was not nearly as impressive as last years.

In spite of technical progress predicting the weather is still very difficult.

3A The art gallery in this street was opened only last week.

In this famous coffee shop you will eat the best doughnuts in town.

Most European banks close extremely early on Friday afternoons.

The government is planning a reform of the educational program.

The recent rainfall has caused very severe damage in the higher valleys.

3B A hurricane was announced this afternoon on the TV.

This rugby season promises to be a very exciting one.

Science has acquired an important place in western society.

The rebuilding of the city started the very first day after the earthquake.

It is getting very easy nowadays to find a place in a nursery school.

4A My grandparents' neighbour is the most charming person I know.

Nobody noticed when the children slipped away just after dinner.

The library is open every day from 8 am to 6 pm.

The city council has decided to renovate the medieval centre.

7 paintings of great value have recently been stolen from the museum.

4B The parents quietly crossed the dark room and approached the boys' bed.

Finding a job is difficult in the present economic climate.

There is an important market twice a week on the main square of the village.

The woman over there is an eminent specialist in plastic surgery.

Most of the supporters of the football club had to travel for an entire day.

Infant Experiment 5, Experiment 6 stimuli

Passages used in segmentation task

The carriage was pulled by two big white horses

He gave her a carriage clock as a birthday present

A train pulls a carriage with lots of people on it

The gentle footman looked after the carriage well

The dialect differs in various parts of the country

The vowels in your dialect determine how you speak

In each region people use a dialect to talk

The Newcastle dialect is perhaps the strangest

The pasture over the hill is lush and green

All over the pasture were beautiful yellow primroses

Whilst grazing on the pasture, the cows fell asleep

The cows and pigs live on the pasture on the farm

A tourist goes to London to see the sights

My husband is going to be a ticket tourist at the end of May

You are called a tourist everywhere when on holiday

St Pauls Cathedral had a tourist trapped in once.

Target words used in segmentation task

Carriage

Dialect

Pasture

Tourist

Appendix C: Adult studies speakers

Details of speakers in adult studies

Speaker	Age	Details	Experiment recording used in
Plymouth speaker 1	40	Born and raised in Plymouth	Adult experiment 1, 2, 3, 5
Plymouth speaker 2	38	Born and raised in Plymouth	Adult experiment 1, 2, 3
Plymouth speaker 3	40	Born and raised in Plymouth	Adult experiment 1, 2, 3, 5
Plymouth speaker 4	36	Born and raised in Plymouth	Adult experiment 7
Plymouth speaker 5	42	Born and raised in Plymouth	Adult experiment 7
French speaker 1	35	Born and raised in Paris, in Plymouth for 12 years	Adult experiment 1, 2, 3, 5
French speaker 2	39	Born and raised in Grenoble standard French accent, in Plymouth for 3 years	Adult experiment 1, 2, 3, 5
French speaker 3	36	Born and raised in Angers standard French accent, in Plymouth for 12 years	Adult experiment 2, 3
Malaysian speaker 1	24	Born and raised in Malaysia, in Plymouth for 3 years	Adult experiment 1, 2, 3, 5
Malaysian speaker 2	21	Born and raised in Malaysia, in Plymouth for 1 year	Adult experiment 1, 2, 3, 5

Malaysian speaker 3	25	Born and raised in Malaysia, in Plymouth for 1 year	Adult experiment 2, 3
Irish speaker 1	51	Born and raised in Cork, Ireland, in Plymouth for 18 years	Adult experiment 5
Irish speaker 2	35	Born and raised in Dublin, Ireland, in Plymouth for 3 years	Adult experiment 5
German Speaker 1	34	Born and raised in Germany, in Plymouth for 2 years	Adult experiment 4, 6, 7
German speaker 2	40	Born and raised in Germany, in Plymouth for 3 years	Adult experiment 4, 6, 7
Hungarian speaker 1	34	Born and raised in Hungary, in Plymouth for 8 years	Adult experiment 4, 6, 7
Hungarian speaker 2	31	Born and raised in Hungary, in Plymouth for 3 years	Adult experiment 4, 6, 7

Appendix D: Infant studies speakers

Details of speakers in infant studies

Speaker	Age	Details	Experiment recording used in
Plymouth speaker 1	20	Born and raised in Plymouth	Infant experiment 1, 3, 4
Plymouth speaker 2	22	Born and raised in Plymouth	Infant experiment 1, 3, 4
Plymouth speaker 3	29	Born and raised in Plymouth	Infant experiment 1, 3, 4
Plymouth speaker 4	30	Born and raised in Plymouth	Infant experiment 1, 3, 4
Plymouth speaker 5	40	Born and raised in Plymouth	Infant experiment 5, 6
Plymouth speaker 6	31	Born and raised in Plymouth	Infant experiment 5, 6
Welsh speaker 1	19	Born and raised in South Wales until at least 18	Infant experiment 1, 2, 3
Welsh speaker 2	20	Born and raised in South Wales until at least 18	Infant experiment 1, 2, 3
Welsh speaker 3	21	Born and raised in South Wales until at least 18	Infant experiment 1, 2, 3
Welsh speaker 4	24	Born and raised in South Wales until at least 18	Infant experiment 1, 2, 3

Scottish speaker 1	20	Born and raised in Edinburgh until at least 20	Infant experiment 2, 5
Scottish speaker 2	20	Born and raised in Glasgow until at least 20	Infant experiment 2, 5
Scottish speaker 3	30	Born and raised in Edinburgh until at least 20	Infant experiment 2
Scottish speaker 4	32	Born and raised in Glasgow until at least 20	Infant experiment 2
French speaker 1	40	Standard Parisian dialect, in Plymouth for 3 years	Infant experiment 4
French speaker 2	36	Standard Parisian dialect, in Plymouth for 12 years	Infant experiment 4
French speaker 3	42	Standard Parisian dialect, in Plymouth for 10 years	Infant experiment 4
French speaker 4	39	Standard Parisian dialect, in Plymouth for 3 years	Infant experiment 4
German speaker 1	34	Born and raised in Germany, in Plymouth for 2 years	Infant experiment 6
German speaker 2	19	Born and raised in Germany, in Plymouth for 2 months	Infant experiment 6