Order effects in English and Urdu speaking infants' and adults' discrimination of non-native consonants: Urdu Affricate /tʃ/-/tʃʰ/ and English approximant-fricative /w/-/v/ contrasts

Mariam Dar

PhD

University of York

Language and Linguistic Science

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ABSTRACT

This thesis examines the decline in non-native consonant discrimination at the end of the first year and perceptual asymmetries that were identified in course of experiments. In Study 1 & 2, 7- and 11-month-old monolingual infants from English speaking homes were tested on the Urdu affricate contrast /tʃʰ/ and /tʃ/. The order of presentation was counterbalanced. Younger infants discriminated the contrast, whereas older infants only showed discrimination when the non-native aspirated affricate /tʃʰ/ was presented first. This led to Study 3, in which the 11-month-olds from Study 2 were tested again at 15 months of age on the same Urdu affricate contrast, with a different word pair, with similar results. In order to test if the same results could be found in infants from a different language background, Study 4 tested bilingual infants from Urdu speaking homes at two age groups, 7- and 11-months of age, on non-native English /w/ vs. /v/. Study 4 found order effect irrespective of age. In both age groups, the discrimination score was higher when the unfamiliar /w/ was presented first. Lastly, in order to find out if these order effects are maintained in adulthood, monolingual English and bilingual Urdu adults were tested in Study 5 on both native and non-native /w/ vs /v/ and /tʃ/ vs /tʃʰ/ contrasts. Only Urdu adults showed asymmetry for the non-native English contrast. These asymmetries can be interpreted in light of the Magnet theory (Kuhl 1986; Kuhl 1991), which explains how prototypicality[1] of a given token and the order in which tokens are presented effects discrimination in a speech perception task.

[1] Prototypicality here refers to how similar a non-native consonant is to any given native token. For example, the Urdu affricate /tʃ/ is native-like to English adults, hence prototypical; Urdu affricate /tʃʰ/ is non-native like and hence non-prototypical.

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AUTHOR'S DECLARATION

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as References.

To Yasir

for his endless support
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CHAPTER 1: INTRODUCTION

1.1 Overview

The way infants learn language has attracted significant attention for forty years or more. The learning process starts with infants being able to detect small differences between speech sounds. Researchers have marvelled at the fact that infants can discriminate speech sounds as early as 2-4 months of age. What is more interesting is that infants can discriminate not only between speech sounds present in the native language, but between most of the sounds on which they have been tested, whether present in the native language or not. Similar *universal discriminatory abilities* extend to musical rhythm, monkey faces or other-race faces, with little or no exposure (Pascalis, Haan & Nelson, 2002; Hannon & Trehub, 2005; Kelly et al., 2007; Weikum et al., 2007).

Infants are constantly exposed to their ambient language and this native language exposure in a social context helps the infant to pick up on the sounds that play a functional role in the native language repertoire. Along with constant language exposure, the maturational process over the first year, including neurological and attentional changes, increases infant sensitivity to the language cues that they are exposed to. Over the same period, due to lack of exposure, the infant's ability to discriminate between non-native stimuli decreases significantly. This process brings a shift from *universal* to *language-specific* perception by the end of first year; infants are no longer able to discriminate non-native speech stimuli, as demonstrated by many studies using a range of non-native contrasts (Werker, Gilbert, Humphrey, & Tees, 1981; Werker & Tees, 1983, 1984; Kuhl, Williams, Lacerda, Stevens & Lindblom, 1992; Best, McRoberts, LaFleur & Silver-Isenstadt, 1995; Polka & Bohn, 2001; Werker & Tees, 2002; Best & McRoberts, 2003; Kuhl, Conboy, Padden, Nelson & Pruitt, 2005; Kuhl et al., 2006). This perceptual decline has been termed *perceptual narrowing*; for vowels, perceptual narrowing is said to happen earlier than for consonants (Polka & Werker, 1994). However, there are many non-native consonant contrasts that have not yet been tested. Do infants show a decline in perception for all possible non-native consonant contrasts at the same time? Or does the decline happen earlier for some consonant contrasts than for others? Note that the same trajectory is not shown by all speech contrasts. Fricatives are one such example; many studies have demonstrated infants' difficulty with fricative discrimination, even for fricatives that play a functional role in the native language (Aslin & Pisoni, 1980; but see Tsao, Liu & Kuhl, 2006). Other contrasts are discriminated at an early age but the ability to discriminate them shows enhancement at later stages (e.g., /r/ vs. /l/, see Kuhl et al., 2006). However, apart from a few exceptions such as fricatives, a perceptual decline has been demonstrated in most of the contrasts tested.

This perceptual shift that happens at the end of first year is suggested to be the result of category learning (Maye, Werker, & Gerken, 2002; Maye, Weiss, & Aslin, 2008; Wanrooij, Boersma & van Zuijen, 2014). With repeated exposure, the speech stimuli start getting organized into speech categories by the infant in line with the phonetic inventory of a given ambient language. For example, if two sounds contrast in a language, their phonetic realization will be bimodally distributed (Pierrehumbert, 2003; Maye, Weiss & Aslin, 2008), which will result in the formation of two separate phonetic categories, one for each of the sounds. However, if the speech sounds do not contrast, only one category is formed. This category learning can influence the way infants discriminate both native and non-native language contrasts.

There have been many studies on the internal structure of the speech categories that are formed by infants (Kuhl 1986; 1991; Iverson & Kuhl, 1995). The exemplar-based approach to speech perception suggests a way that the individual speech tokens may get internally organized into these categories; the most typical exemplar occupies the centre position, whereas the most atypical ones are found at the category boundary (Kuhl, 1986; Kuhl, 1991; Iverson & Kuhl, 1995). In such a framework, we can expect the categorizations of sounds to show effects of prototypicality,[2] centrality, and fuzzy boundaries (Grieser & Kuhl, 1989). Kuhl and her colleagues have demonstrated that the internal structure of any given category has a role to play in perception, such that discrimination is affected by the distance of the speech tokens from the centre of the category. This leads to an asymmetry in which discrimination from non-prototypical *('less typical tokens'*) to a prototypical token (*'most typical')* is significantly better than discrimination between two non-prototypical tokens (Kuhl 1986, 1991). These perceptual asymmetries have been tested largely for vowels and native-language consonants; very little evidence is available for asymmetries in non-native consonant perception. This might be due to the fact that consonants have been assumed to be perceived more categorically than vowels (Eimas, Siqueland, Jusczyk & Vigorito, 1971; see also Damper & Harnad, 2000; Livingston, Andrews & Harnad, 1998).

[2] In an exemplar model framework, reference to a prototype does not imply reference to an abstract summary or ideal representation but to a particular exemplar of that category. The prototypical exemplar is the member of the category that is most similar to the largest number of other category members and is therefore also unlikely to be highly similar to exemplars from other categories (Medin & Schaffer, 1978; Hahn & Chater, 1998).

Very few studies have explored asymmetry in non-native consonant perception. In general, asymmetries in speech perception have been linked either to inherent auditory processing differences that result from salient acoustic properties of the sounds in question (Polka & Bohn, 1996; 2003) or to the relationship between the various tokens of a category, as a product of early language exposure (Kuhl, 1986; 1991). In the present research, in the course of five studies, the thesis attempts to explore the developmental changes in the non-native consonant perception of participants from two different language backgrounds, on non-native affricate and approximant-fricative contrasts. Throughout these studies asymmetries remain the focal point, in an attempt to identify the presence and origin of such asymmetries in non-native consonant perception.

1.2 Motivation for the research

The following points motivated the present study;

a) Very few studies have tested infants on a non-native affricate contrast.

b) No previous study has provided significant results for asymmetry in non-native consonant perception at the end of the first year.

a. There has been no study on the perceptual development of Urdu infants from Pakistan.

Following the first study, all the experiments were designed to investigate and understand the results of the preceding studies. Each study led to a different set of research questions and for that reason the research questions are presented separately, after every study, in the order in which they arose.

1.3 Literature Review

Considerable research on infant speech perception has demonstrated that the world of sensory impressions is not a ‘blooming, buzzing confusion’, as William James (1890, p. 448) suggested. Auditory experience begins in the womb in the last trimester of pregnancy which tunes neonatal perception: The liquid medium of the fetus allows the infant to become familiar with the prosody of the ambient language while masking the high frequencies needed for segment discrimination (Lecanuet, 1993; Cooper & Aslin, 1994). Many studies have demonstrated newborns’ preference for their native language, their mother’s voice and songs heard prenatally. This shows that the information present in the environment is readily processed by the infant, which shapes infants’ perceptual preferences even before birth.

The first study to demonstrate infant’ perceptual sensitivity to the native language was by Eimas et al. (1971). Eimas and his colleagues (1971) tested infants on the English /ba/-/pa/ distinction using the high-amplitude sucking procedure (HAS). It was found that infants as young as 1-4 months of age could not only discriminate speech sounds categorically, but the phonetic categories found in infants were comparable to those of adults. Shortly thereafter it was found that young infants could successfully discriminate not only the contrastive sounds of the ambient language but the majority of non-native contrasts they were tested on. Trehub (1976) demonstrated that 1- to 4-month-old infants from English-speaking homes were not only able to discriminate between oral and nasal vowels /pa/ vs. /pã/ (although a contrast between oral and nasalized vowels does not exist in English) but also the natural speech tokens of /ʒa/ vs. /r̝a/ from Czech. Streeter (1976) also reported Kikuyu infants’ discrimination of the English /ba/-/pa/. These experiments on infants as young as 1-4 months of age, when experience with the native language had not yet shaped infant's perceptual capabilities, demonstrated that infants are born with the mechanism to respond to most of the speech contrasts. These studies gave the impression of *'universal'* capacities for discrimination of speech contrasts in the first few months of life. Also note that these universal capacities of infants in the first few months have not only been demonstrated for speech but across other perceptual domains. Many studies have shown young infants discrimination for other-race faces (Kelly et al., 2007), different monkey faces (Pascalis, Haan & Nelson, 2002) and subtle non-native musical rhythms (Hannon & Trehub, 2005; Weikum et al., 2007)

In the early studies, not only was it thought that the discriminatory behaviour of infants was the result of the universal perceptual abilities they are born with, but that the innate perceptual mechanism was unique to the perception of speech signal, with little room for experience/exposure in discriminatory behaviour. However, these claims were challenged on many grounds. In animal perception studies evidence was presented from animals whose auditory mechanisms are close to that of humans. Kuhl & Miller (1975) showed 'categorical perception' in chinchillas who were trained on computer-synthesized versions of /da/ and /ta/. In a later study, Kuhl & Miller (1978) replicated and extended this experiment, testing labial, alveolar and velar pairs contrasting in Voice Onset Time (VOT), which is the length of time that passes between the release of a stop consonant and the onset of voicing, and found that the VOT boundary in chinchillas shifts with place of articulation in the same way as it does for humans. Kuhl & Padden (1982, 1983) further tested macaque monkeys on VOT and place contrasts in stop consonants to show that the regions of enhanced discriminability in the macaques matched with humans and chinchillas. These experiments strongly suggested that salient auditory boundaries unique to the overall structure of the mammalian hearing system, not just the human auditory system, are most likely responsible for the categorical perception observed in the studies.

Evidence from non-speech stimuli has provided further evidence in this regard. Aslin & Pisoni (1980) argued that the categorical-like-discrimination of the infants in Eimas et al. (1971) does not necessarily point towards a linguistic mode of processing as at least one major sensory (non-linguistic) factor, namely, the discrimination of temporal order, can account for VOT discrimination (Hirsh, 1959; Pisoni, 1977). Temporal order exhibits categorical perception with approximately a 20-msec boundary; thus any difference that is smaller than 20 milliseconds is not recognised by the auditory system (Aslin & Pisoni, 1980). Also, many studies (Miller, Wier, Pastore, Kelly & Dooling, 1976; Pisoni, 1977) have demonstrated that several classes of non-speech signals containing ‘speech-like’ acoustic attributes can be perceived categorically by adults. Pisoni (1977) tested adults using synthetic speech stimuli differing in VOT, creating a Tone Onset Time (TOT) continuum, which consisted of two tones that were either presented simultaneously or separated by various onset asynchronies mimicking the VOT onset times. The adults divided the non-speech continuum into three perceptual categories similarly to the way they would divide a speech continuum, leading to areas of enhanced discriminability. Young infants also show categorical-like discrimination when presented with non-speech signals differing in rise time (defined as the speed of the rate of change of amplitude modulation) (Jusczyk, Pisoni, Walley & Murray, 1980).

These findings in both adults and infants pointed towards a more general psychophysical basis for the categorical perception of speech. According to Quantal theory (Stevens, 1989) there are regions of acoustic stability in brain separated by regions of instability. It is thus based on the idea that preferred sound categories are selected to occupy the stable regions and to be separated by unstable regions. Kuhl (1987) suggested that the human perceptual mechanism is particularly sensitive to change in these acoustic quantal (or stable) regions in the brain, marking phonemic boundaries for consonants by corresponding to peaks in discrimination (Stevens, 1972, 1989; Studdert-Kennedy, 1980, 1989). Kuhl (1987) points out that these mechanisms may have evolved especially for speech perception, but at the same time evolved not to rule out non-speech signals which mimic the vital features of speech. Thus the evidence presented in non-speech and animal studies suggests that speech is perceived by a perceptual mechanism, which is not 'special' to speech. What it does imply is that the infants respond primarily to the psycho-physical or sensory properties of speech signals without necessarily interpreting these signals as linguistic entities.

In 1983 Werker & Tees carried out an experiment on English-speaking children at four, eight and twelve years of age, testing them on two Hindi contrasts; [tʰa] vs. [dʰa] and [ʈa] vs. [ta]. It was found that none of the children were able to discriminate these contrasts. Werker & Tees (1984) tested six-month-old English-learning infants, English-speaking adults and adult native speakers of Thompson on a pair of Thompson consonants, glottalized velar stop [k'i] vs. uvular stop [q'i]. The results showed that English infants and Thompson adults were able to discriminate between the Thompson pair, whereas English adults could not. The second experiment in the series tested English infants aged 8-10 months and 10-12 months, on non-native pairs from Hindi and Thompson (an unvoiced unaspirated retroflex/dental contrast [ta] vs. [ʈa] from Hindi and glottalized velar stop/uvular contrast [k'i] vs. [q'i] from Thompson). At 8-10 months of age most infants discriminated the non-native contrasts while at 10-12 months most infants did not. In a follow-up experiment, six 6-month-olds from English speaking homes from Experiment 1 were tested again at 8-10 and 10-12 months of age on three contrasts (Hindi [ta] vs. [ʈa]; Thompson [k'i] vs. [q'i]; English [ba] vs. [da]). Only three infants discriminated the Thompson contrast at 8-10 months, and neither the Hindi nor the Thompson contrast was discriminated by 10-12 months of age. Werker & Tees concluded that a 'selective tuning of initial sensitivities in accordance with a specific phonology...occurs at about the age that the child is beginning to understand and possibly produce sounds appropriate to his/her native language' (1984, p. 62).

Numerous studies after Werker, Gilbert, Humphrey & Tees (1981) and Werker & Tees (1983, 1984) showed the decline in the perception of phonemic contrasts that do not exist in the native language. Best & McRoberts (2003) assessed discrimination of three Zulu distinctions on infants from English speaking homes at 6-8 months and 10-12 months of age using three stimuli contrasts /ɬ/-/ɮ/, /kʰa/-/k'a/, and /pu/-/ɓu/. The results revealed that 6-8 month olds discriminate all three Zulu contrasts while the 10-12 month olds showed a decline in discrimination for one or more contrasts. In 2002, Werker & Tees tested 6-7-month old infants and English-speaking adults on the English alveolar-bilabial /ba/-/da/ distinction and Thompson glottalized unvoiced uvular-velar distinction /`ki/-/`qi/. The results showed a decline in cross-language speech perception with age. Of special interest is the fact that the longitudinal studies have yielded similar results in this regard. Werker & Tees (2002), in another experiment tested 6 English-learning infants at three ages: a) 6-8 months, b) 8-10 months and c) 10-12 months. Infants were tested on three contrasts: Hindi /ʈa/-/ta/, the Salish contrast /`ki/-/`qi/ and the English contrast /ba/-/da/. It was found that at infants at 6-8 months of age discriminated all three contrasts but by 10-12 infants only discriminated the English contrast.

The neural correlates of perception have also been shown to exhibit a significant decline over the first year. Rivera-Gaxiola, Klarman, Garcia-Sierra & Kuhl (2005) carried out a longitudinal study of American monolingual infants from seven to eleven months of age, examining their auditory event-related potentials to native and non-native contrasts. Three consonant–vowel (CV) syllables differing in voice-onset time (VOT) were used: voiced /da/ (phonemic in Spanish but not in English), voiceless unaspirated alveolar consonant (phonemic in both English and Spanish (heard as /ta/ in Spanish and /da/ in English), and voiceless aspirated /ta/ (phonemic in English but not in Spanish). The findings demonstrated that, at the group level, 7-month-olds' ERPs showed successful discrimination of both native and non-native phonetic contrasts, whereas the ERPs of 11-month-olds showed discrimination of only the native phonetic contrast. In a similar study by Cheour et al. (1998) a visible decline in the discrimination was seen in 11-month-old Finnish infants' neural responses to a non-native Estonian contrast /ɤ/ - /ø/; 6-month-old Finnish infants showed discrimination for both native and non-native contrasts. Both these studies demonstrate that with age, infants show a less robust discriminatory response to a contrast that does not convey differential meaning in their native language.

It should be noted that the age of the decline in non-native speech perception is consistent in all of the above mentioned experiments. Werker et al. (1981, 1984) demonstrated the decline in perception discrimination at the end of the first year. Other studies in this field have also shown the decline around the same time (Best, McRoberts, LaFleur & Silver-Isenstadt, 1995; Best, McRoberts & Sithole, 1988;

Cheour et al., 1998; Best & McRoberts, 2003; Rivera, Silva & Kuhl, 2005; Kuhl et al., 2006; Tsao, Liu, & Kuhl, 2006). Note that this decline occurs not only in the speech but many domains of perception. Pons, Lewkowicz, Soto-Faraco & Sebastián-Gallés (2009) showed 6-and 11-month-old Spanish- and English-infants silent video clips of a female bilingual Spanish-English speaker repeatedly producing a /ba/ and a /va/ syllable. Two auditory familiarization trials of /ba/ and /va/ were also presented in between the video clips. It was found that at 6 months of age there was an increase in looking time to the video clip after the auditory familiarization at both age groups. However, in older groups only the infants from English-speaking homes showed a significant increase in looking times. Further testing of Spanish- and American-speakers has demonstrated the maintenance of this decline in inter-sensory perception into adulthood. A similar decline has also been demonstrated towards the end of first year in infants' discrimination of other-race faces, monkey faces and non-native music (Pascalis et al., 2002; Sangrigoli & de Schonen, 2004; Kelly et al., 2005; Sangrigoli et al., 2005; Lewkowicz & Ghazanfar, 2006; Kelly et al., 2007; Weikum et al., 2007).

The decline in the perception of speech contrasts (as well as other sensory stimuli) was later termed 'perceptual narrowing' (Kuhl, 2004) and understood to be the result of category learning. Early perceptual abilities can be looked upon as a multidimensional continuum which allows infants to recognise small auditory differences. It is important to note that the infants have *universal perceptual abilities* because at this stage infants do not look/listen for categories but rely on auditory processing simply to process the auditory stimuli they are exposed to. Native language exposure that is frequent and consistent teaches the infants to ignore or pay attention to a given contrast, depending upon whether or not that contrast plays (or not) any functional or phonemic role in the language.

Putting it simply for the sake of exposition, we can assume that if two sounds contrast in a language (i.e., if they are distinct phonemes), their phonetic realization will be bimodally distributed (Pierrehumbert, 2003; Maye, Weiss & Aslin, 2008). This leads infants to form separate phonetic categories, one for each of the sounds. When the speech sounds do not contrast, input speech is likely to provide a broader or unimodal range of variation. Various studies have provided evidence of such learning. It is generally assumed that children begin to induce phonological categories *bottom-up* on the basis of their discovery of clusters of sounds in perceptual space (Pierrhumbert, 2003). This was demonstrated by Maye, Werker & Gerken (2002). The authors presented 6- and 8-month old infants from English speaking homes with a continuum from voiced unaspirated to voiceless unaspirated alveolar stops [da]-[ta]. One group was given unimodal exposure, the other group bimodal exposure. After that, both groups were tested with tokens from the extremes of the continuum to which the two groups had been exposed equally. At both ages, only the infants who were given bimodal exposure were successful in discrimination, showing that only in that condition are the two separate phonetic categories formed (see Figure 1). Maye & Gerken (2001) tested English speaking adults with similar stimuli and found comparable sensitivity to distributional characteristics. In short, distributional learning refers to the detection of cluster of tokens in a psychophysical space. For example, consider that all tokens for the vowel [i] are similar to each other and do not have much space/distance between them. In addition, that particular cluster of tokens is not only distinct from the cluster of tokens for other vowels but also has much more distance/space between it and the cluster of other vowel tokens than between the tokens within the [i] cluster. This could make the infants assume that [i] is a category. The same process leads to the formation of phonetic categories for any given language.

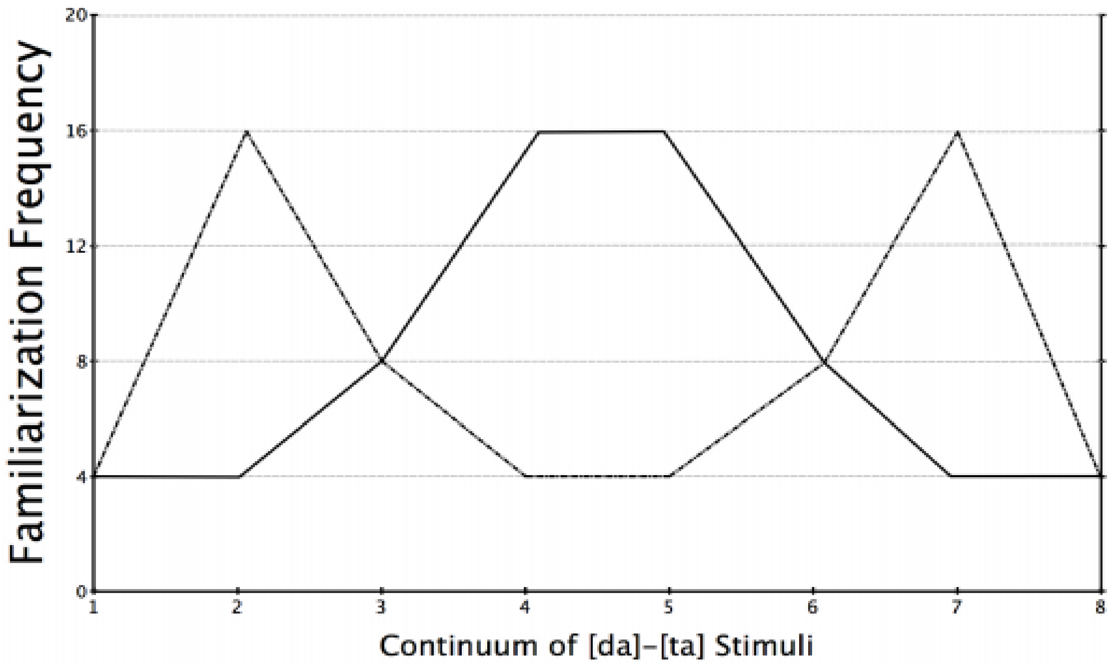

Figure 1 Bimodal vs. unimodal distributions of [da]-[ta] stimuli. The dotted line shows the presentation the presentation frequency for the bimodal group, the solid line that for the unimodal group (Maye, Werker & Gerken, 2002, p. B104, Fig. 1).

Category learning has also been described as forming clouds in multidimensional space. In the words of Goudbeek, Swingley & Smits (2009), perceptual categories exist in a space with continuous dimensions. As listeners hear sounds, they evaluate each sound on a number of dimensions and map the sound to a point in the multidimensional space. As similar tokens keep on getting mapped to the same point or near it that leads to the *clouds* of points. As the exposure keeps increasing, distinct clouds appear in that multidimensional space and listeners create categories by associating each cloud with a distinct category. This recognition of the patterns or clouds in multidimensional space leads to category learning. These changes in the perceptual sensitivity in the first year of life have been referred to as *functional reorganization* (Werker & Tees, 1984).

It is important to mention that it is not just exposure to the native language but exposure to the native language being used in a social environment on a day to day basis that leads to this functional reorganization. This important perspective has been demonstrated by Kuhl, Tsao & Liu (2003). The study exposed 9-month-old American infants to native Mandarin Chinese speakers in 12 laboratory sessions, whereas a control group participating in the same number of language sessions heard only English. It was found that infants exposed to native Mandarin speakers did not show the decline observed in the English control group with respect to a Mandarin contrast. In the follow up experiment, infants who were exposed to the same native Mandarin speakers via audiovisual or audio-only recordings performed similarly to the control group. This demonstrates the importance of the social interaction for the infants: Infants can learn language only by experiencing native speakers' using that language around them. Through regular exposure, sensitivity to the non-native sounds decreases as the native language's frequent input starts shaping infants' repertoire. However, with specific training sensitivity can be reinstated to some extent (Kuhl, Tsao & Liu 2003).

This category learning, which results from native language exposure in a social context, can influence the way speakers discriminate both native and non-native language contrasts. Taking an exemplar approach we can say that the representations of sounds are built from multiple exemplars organized in a multidimensional space that will lead to prototypicality, centrality, and unclear/fuzzy boundaries. The exemplar model is based on the assumption that a trace of every member of that category is stored in the brain and all the exemplars of a given category are organized on the basis of their similarity to the ideal/or typical exemplar (Minda & Smith, 2002). The stronger the representation, the denser the area connecting the exemplars to each other; some areas will have less strongly connected exemplars, leading to weaker representations and sparser areas. In any given category, the most typical exemplars will occupy the center and the less typical will be at the periphery (see Iverson & Kuhl, 1995). Any new to-be-categorized item is compared with all of the stored exemplars; thus categorization is a function of which group of stored traces the item is most like, and how much it is like them.

These effects have indeed been found for vowels. Vowel categories are understood to be built around prototypes (Grieser & Kuhl, 1989) and to have graded membership and fuzzy boundaries (Taylor, 2008). Kuhl and her colleagues (Kuhl 1986; Grieser & Kuhl, 1989; 1991) have proposed that discrimination is affected by the relationship between the *most typical* (prototypical) tokens of a given category and the less typical ones. That is, for vowel categories some areas in the perceptual space serve as *category centers*, providing a reference point for generalization to novel exemplars. In a test of adult perception of differences between the within-category exemplars of the vowel /i/, English-speaking adults rated sixty-four different variants of the stimuli on *goodness* (defined as sounding ‘natural’). It was found that the ratings were consistent around a particular location in the vowel space – Kuhl (1991) referred to it as a *hot spot* that received consistently high ratings across listeners; those vowels were perceived as better exemplars of the category than others. It is important to note that the adults were not provided with any special instructions as to what to base their category goodness judgements on; they had to rely on an internal standard of the *ideal* vowel. The fact that adults’ ratings were so consistent suggested that adult listeners had an internal standard for the vowel /i/ that was quite similar. In a follow-up experiment, Kuhl (1991) tested sixteen English speaking adults using the same vowel /i/ and its variants. The listeners discriminated members of the vowel category /i/ using two different variants of vowel, the prototype (P) and the non-prototype (NP). They first heard the *referent* speech sound, which was changed to the comparison vowel after a few repetitions and they were asked to respond if the change was detected. It was found that the discrimination was more difficult in the P condition than in the NP condition. Thus, generalization was significantly higher when the prototype served as the referent, indicating that adults perceived the prototype as more similar to its surrounding variants (or produced a broader generalization) when compared with the non-prototype in relation to its surrounding variants. This experiment clearly showed that adults' perception of speech stimuli was strongly affected by typicality and direction: Only when the prototype of the category served as the referent (or presented first), the other members of the category were perceived as more similar to it. The non-prototype of the category did not function in this way; thus the generalization was seen only in one direction.

These experiments on adults raised many questions. What led to this similarity in the internal structure of categories in adults? And was it possible to find similar notions of typicality in infants? In order to find out, thirty-two English-learning infants were tested with the same variants of vowel /i/ to see whether adults' goodness ratings correlated with infants. Like adults, infants were exposed to two referent conditions. Infants in the P condition were tested with the prototype vowel and its thirty-two surrounding variants; infants in the NP condition were tested with the non-prototype vowel and its thirty-two surrounding variants. Responses from infants mirrored the result from adults; stimuli defined by adult speakers of the language as better exemplars or prototypes of the category resulted in greater generalization to other members of the category. The prototype appeared to function like a perceptual magnet, even for infants only 6 months old. This directional asymmetry in both infants and adults suggested that the prototype is an especially powerful perceptual anchor[3] for the category as it pulls other stimuli toward the centre of the category, effectively shortening the perceptual distance between stimuli at the outskirts of the category and the prototype centre. This effect was termed *perceptual magnet* (Kuhl, 1991).

Taken together, although these experiments showed that both infants and adults shared the same notion of typicality in speech perception, they did not throw any light on the origin of this effect. One speculation was that these typicality effects were inherent to the human auditory perceptual system. Another possibility was that early language experience leads to the formation of an internal structure of categories in which the most typical exemplar occupies a central position. One way to test whether the effects were inherent was to examine the effect in a nonhuman primate, such as monkeys, whose auditory abilities matched to those of man. Previous work had also demonstrated that effects such as categorical perception can be replicated in monkeys (Kuhl, 1987, 1988). In order to verify if monkeys would show the typicality effect similar to humans, Kuhl (1991) tested sixteen male monkeys in a procedure that was similar to the one used previously with infants and adults. The results from this experiment showed no speech prototype effect for the monkeys; generalization around the prototype and the non-prototype was equal. Thus, unlike

[3] This refers to the generalization to the other members of the category that occurs when the highly representative exemplar (or prototype) of a category is presented first. The presentation of a prototype activates a given category, which makes it easier and quicker to relate to the following non-prototypical exemplars, mimicking a magnet effect.

humans, the perception of speech sounds was unaffected by category goodness. These findings on monkeys ruled out a basic auditory-process explanation for the results. Kuhl (1991) concluded that the effects observed in humans were due to language experience and could be seen in infants as early as 6-8 months of age. Many cross-linguistic studies have shown that by this time infants have begun to organize their speech categories in a way that leads to a decline in non-native speech perception (Polka & Werker, 1994; Bosch & Sebastián-Gallés, 2003; Tsuji & Cristia, 2014). Thus, by 6 months of age infants have had sufficient experience with the ambient language to form representations of at least some of the vowels of their native language.

Note that these early studies by Kuhl tested within-category variants of the same vowel. However, according to Kuhl's interpretation (1991), the same concepts of prototypicality, centrality and anchor point can be applied to the sound variants belonging to different categories. For example, if only one of sounds from a given non-native speech contrast exists in the native language, then we can think of the sound resembling a native category as prototypical and the other one as a non-prototypical one. In that case, the sound similar to the native language prototype will act as a magnet, pulling the perception of the non-prototypical sound itself. This can explain the decline in discrimination for non-native contrasts observed within the first year.

Similar to Kuhl's model, the Perceptual Assimilation Model (PAM: Best, McRoberts & Sithole, 1988; Best, 1991; Best, McRoberts, LaFleur & Silver-Isenstadt, 1995; Best, McRoberts & Goodell, 2001) describes a process by which listeners perceptually assimilate non-native sounds (whether vowels or consonants) to their own phonemic inventory; non-native sounds are perceived with better or worse accuracy depending on how closely the sound maps to existing categories in the listeners' own native sound system. According to this model, listeners discriminate non-native sounds with respect to their phonetic similarity with the native sounds, the detection of commonalities in the articulators, constriction locations and/or constriction degrees used. Best identifies four ways in which a non-native contrast can be assimilated after infants have formed distinct phonetic categories. A non-native contrast may:

1 resemble two different native phonemes, leading to successful discrimination, for example, Ethiopian labial vs. dental ejectives are assimilated to different English categories, /p/ vs. /t/.

2 resemble just a single category of the native language, instead of two separate categories, for example Thompson velar and uvular ejectives are assimilated to a single English category /k/.

3 resemble a single category, but with a better phonetic fit with the category for one member of the contrasting pair. For example Zulu, voiceless plain velar stop /k/ vs. velar ejective /kʔ/ are both assimilated to English /k/.

4 fail to resemble any native categories, like Zulu clicks, which do not resemble any sounds in English.

Best & McRoberts (2003) later added that a *within-organ contrast* (two different gestures made by same primary articulator) is more difficult than a *between-organ contrast* (Same gesture produced by different primary articulators). Experiments on such non-native contrasts between 6-12 months of age have supported this claim (Best & McRoberts, 2003). In Kuhl's magnet theory a listener's native language learning/experience determines how closely the non-native contrast relates to the native ones, whereas in PAM the discrimination for non-native contrasts is not systematically related to whether or not the phonetic features (or categories) occur within the listeners' native language; thus, early exposure to any speech contrast, or lack thereof, does not guarantee good versus poor discrimination (as the dimensions are articulatory). Also note that listeners in Kuhl's magnet theory compare the non-native contrasts to what they already know, in PAM listeners approach the discrimination task with a focus on articulators, constriction location, and degree.

Another finding that fits within the exemplar model framework is that of order-related asymmetry in discrimination between more prototypical and less prototypical tokens within a vowel category (such asymmetries have been reported for native language vowel contrasts for adult speakers: Repp, Healy, & Crowder, 1979; Cowan & Morse, 1986; Iverson & Kuhl, 1995). In a study of between-category vowel discrimination in English-learning infants (Polka & Werker, 1994), change in a given direction ([y] before [u]) was discriminated better than the change in the reverse order. Infants discriminated the vowels only when the *non-prototypical* (non-English like) front-rounded vowel was presented before the *prototypical* (English-like) back-rounded vowel[4]. The authors first attributed the results to the magnet effect: [u] and [i] are the more familiar vowels for English listeners, while [y] and [ʏ] are non-native; thus, as an anchor point [u] pulled in the perception of the following [y], resulting in assimilation when it was presented first.

[4] The presumed lack of exposure to fronted /y:/ for English infants may be questioned, however, as there is abundant evidence of fronting of /u:/ in English dialects around the globe: North America, South Africa, Australia and New Zealand (Haddican et al., 2013).

However, Polka & Bohn (1996) later suggested that the anchor[5] point plays a role independently of the status of a given vowel in native language phonology. In their study 6-8 and 10-12-month-olds from English and German families were tested on an English (non-German) /ɛ/-/æ/ contrast and a German (non-English) /u/-/y/ contrast. Discrimination was found to be easier from /y/ to /u/ and /ɛ/ to /æ/ than from /u/ to /y/ and /æ/ to /ɛ/, with age or native language not affecting the results. In another study (Polka & Bohn, 2011) large numbers of Danish-learning infants of 6-9 months of age were tested on a Southern British-English contrast, peripheral /ɑ/ vs. /ʌ/, and two native contrasts, /e/ vs. /ɛ/ and /e/ vs. /ø/. It was found that both younger and older children discriminated the non-native vowel more successfully when the more central/less peripheral[6] vowel was presented first. The authors attributed the asymmetry to an innate perceptual bias not dependent on language experience or familiarity from the native language. The findings led Polka & Bohn (2011) to introduce the Natural Referent Vowel (NRV) model, which speculates that 'vowels with extreme articulatory-acoustic properties…act as natural referent vowels…by attracting infant attention and providing stable perceptual forms' (p. 474). Note that in NRV framework, the anchor vowel is salient in comparison to other vowels due to its inherent acoustic properties and is independent of language learning (between-

[5] In magnet theory "anchor point" refers to an exemplar or prototype from within a given category that is highly representative of that category which leads to greater generalization to other members of the category, when presented as the first instance. Thus the typicality of the exemplar and direction in which it is presented turns it into an anchor point in a given discrimination task. In Polka and Bohn (1996) "anchor" point/vowel is the most acoustically salient vowel within the overall vowel space. An anchor vowel is acoustically salient due to its extreme position in the vowel space and small extent of overlap with other vowels. It is easily recognisable by infants and that facilitates access to other vowel categories. Thus, Kuhl's anchor point is related to the internal structure of categories and how various exemplars are organized within a given category, whereas Polka and Bohn's (1996) anchor point is dependent upon acoustic salience of a given vowel in comparison with other vowels in a vowel space.

[6] Kuhl (1986, 1991, Grieser & Kuhl, 1989) and Polka & Bohn (1996) use the word 'peripheral' in different ways. Kuhl tested different variants of the same vowel (within-category), whereas Polka and Bohn (1996) tested vowels which occupy different positions in the vowel space (between-category). In Kuhl's studies, the central (typical) exemplars of the vowel category are tested against the peripheral (atypical) exemplars of the same vowel category. In Polka and Bohn (1996), the central and peripheral vowels are defined within the vowel space in comparison with other vowels. Central vowels are those that occupy the centre position in the vowel space and peripheral vowels are those located further away from the centre.

category anchor point), whereas in magnet theory, early language experience plays crucial role in determining the status of an anchor vowel within a given category (within-category anchor point).

There have also been other reports of asymmetries in vowel perception which demonstrate the role of peripheral vowels in the asymmetry in early vowel discrimination. Swoboda, Kass, Morse & Leavitt (1978) tested English-learning infants of eight weeks of age on the discrimination of synthetic vowels in an /i/-/ɪ/ continuum and found that discrimination was always better from the less peripheral /ɪ/ to the more peripheral /i/ vowel (see also Desjardins & Trainor 1998). Similar asymmetries have been reported in infant perception of non-native vowel contrasts (Best et al., 1997). Thus, it has been suggested that peripheral vowels play a crucial role in infants not only in early vowel discrimination but also in acquiring additional categories. As infants continue to gain language exposure they access other vowel categories, which results in the readjustment of the vowel space according to the vowel inventory specific to the native language.

Note that in these studies of vowel discrimination the asymmetry was attributed to initial biases at birth, before early experience could play a role. As language experience starts shaping infants' phonological system in line with the native language, a shift in the role of the anchor vowel has been reported. Pons, Albareda-Castellot & Sebastian-Gales (2012) traced discrimination of the /i/-/e/ contrast by Catalan and Spanish learning infants. At 4 and 6 months of age Catalan- and Spanish-learning infants exhibited similar performance; infants from both language groups showed directional asymmetries towards the more peripheral vowel /i/ (infants looked significantly longer only when the more peripheral vowel /i/ was presented second. However, in 12-month-olds the asymmetrical pattern shifted towards the vowel that occurred more frequently in their native language environment. The authors noted that perceptual or acoustic bias plays a role in infants before perceptual reorganization. With an increase in experience with the native language through language input, infants get tuned to the phonological categories of ambient language; in a discrimination task, the frequently occurring vowel acts as referent. This change reflects the restricting of the vowel space resulting from the increased knowledge of the distributional properties of the ambient language.

It is important to point out that the asymmetries in vowel discrimination in infant perception can be classified into two types. One is suggested to be the result of biases inherent to the perceptual system (or to its interactions with the production system, as postulated by Stevens - e.g., Stevens & Keyser, 2010); this asymmetry is demonstrated from very early stages and is thought to be related to the perceptual mechanisms available to infants from birth. The other asymmetry can be attributed to native language exposure/learning and develops with age (e.g., Magnet theory).

Note that asymmetries in vowel perception have been investigated based on the understanding that vowels are not rigidly organized into clear-cut categories and are more phonetically gradient as compared to vowels (see e.g., Pierrehumbert, 2003). Consonants, however, have traditionally been assumed to have all-or-none membership or better-defined boundaries, a view which fits with the finding of infant categorical perception (Eimas, Siqueland, Jusczyk & Vigorito, 1971; Livingston, Andrews & Harnad, 1998; Damper & Harnad, 2000). Despite the view that consonants are perceived categorically, a number of studies have not only reported that within-category tokens may be discriminable (Miller, 1994) but also that these within-category distinctions affect lexical processes (Dahan, Magnuson, Tanenhaus & Hogan, 2001; McMurray, Tanenhaus & Aslin, 2002). This supports an exemplar view of consonant perception, proposing that the consonants are centered around prototypes, with graded membership and fuzzy boundaries (see also Pierrehumbert, 2003).

McMurray & Aslin (2005) familiarized 8-month-olds with one member of each of several minimal pairs (e.g., *pear – bear*). Half the infants were familiarized with a word with a voiced onset stop and half with a word with an voiceless onset stop. Infants were then tested on those same words, their minimal pair and a variant of the familiarized word whose onset, though still within the same voicing category, was shifted towards the other voicing category. Infant looking times showed that they distinguished not only between the between-category variants but also between the within-category variants. A sizeable body of work with adults has also provided evidence against the strong version of categorical perception (Pisoni & Lazarus, 1974; Pisoni & Tash, 1974; Carney, Widin, & Viemeister, 1977; Miller, 1997).

Indeed, both Kuhl and colleagues' NLM-e model and Best's PAM refer explicitly to consonants, treating them as being organized into the same kinds of categories as vowels, centered around the most typical exemplar (prototype). Any token's position in a given category is determined by its distance from the centre. The most typical tokens occupy the central position, whereas the less typical ones are found near the boundary. Any to-be categorized token will be perceived depending upon how closely it relates to the other tokens in the given category. The generalisation is dependent upon the typicality of the given token and direction in which it is presented. Much greater generalization occurs when the initial instance is highly representative of the category as a whole. If not, no typicality effects are seen. Moreover, even when a non-native consonant pair is perceived as belonging to the single native category, one consonant will be perceived as a better fit than the other (Best, 1993). For the between-category comparison a similar mechanism can be expected in the light of magnet theory. Take, for instance, the case of the Urdu affricate pair /tʃ^{h}/ - /tʃ/ (used in the present study), which is a foreign contrast for infants from English-speaking homes and which assimilates to a single native category /tʃ/ in English. In the light of the magnet effect it is speculated that if the Urdu affricate /tʃ/ is presented first to English-learning infants, it will assimilate to the closest native prototype /tʃ/. As a result, the perception of the comparison consonant /tʃ^{h}/, presented afterwards, will be affected by priming; since the category /tʃ/ will already be activated, the interpretation of following affricate /tʃ^{h}/ is more likely to be pulled towards it. What makes this magnetic pull even stronger is the commonalities shared by these two affricates (manner of articulation, place of articulation); the only difference is aspiration. This will make it easy for /tʃ/, which is highly representative of the native category /tʃ/, to generalise to the non-prototypical exemplar /tʃ^{h}/, shortening the perceptual distance between the two consonants and leading to poor discrimination.

These typicality effects in prototypes can be seen in many other studies in cognitive science. For example, Rips (1975) examined the semantic structure of inductive judgments about category members. For a particular category subjects were told that one of the species (e. g., horses) had a given disease and were asked to estimate the proportion of instances in the other species that possessed the same disease. The results showed that the representativeness of the instance initially reported as having the disease affected generalization to other members of the species. Mervis & Pani (1980) have shown that, when the initial exemplar of a category is a particularly good one, people are likely to generalize appropriately to other members of the category, whereas no such generalization occurs when the initial exemplar of the category is a poor one. These studies collectively show that high representativeness or typicality leads to increased generalization: prototypes show increased generalization to other members of the category relative to non-prototypes. The similarity between the perceptual magnet effect for speech and these other findings suggests that prototypes in all domains may function similarly and that the consonant categories will be affected by typicality and directionality in the same way as vowels.

With regards to consonants, there have been reports of asymmetry in discrimination between two consonants that are phonemically distinct in a child's language (e.g., Altvater-Mackensen & Fikkert, 2010; Tsuji, Mazuka, Cristia & Fikkert, 2015; Nam & Polka, 2013). Alvater-Mackensen & Fikkert (2010) reported that Dutch-learning 14-month-olds could discriminate the minimal pairs /vas/ and /bas/ in a word-learning task when the fricative /vas/ was presented first; half of the infants were habituated to the word-initial stop /bas/ and tested with the word-initial fricative /vas/ and the order was reversed for the other half. These results were attributed to emerging phonological representations in early lexical development. The authors suggested that the asymmetries observed were related to whether or not a feature was specified in the representation. As pointed out by Lahiri & Reetz (2002), specified features match with a small range of sounds only, while unspecified features tolerate a much wider variety of sounds as matching. Consequently, children only detect changes that involve the substitution of a specified feature, such as labial, but not changes that involve the substitution of an unspecified feature, such as coronal. Fricatives are specified in lexical representation by the phonological feature [continuant] but stops remain unspecified. The asymmetries in perception, according to the authors, resembled errors in early production where fricatives are substituted by stops but not vice versa. Similarly, Tsuji et al. (2015) tested Japanese and Dutch 4- and 6-month-oldson /n/ vs. /m/ contrast and found discrimination only if they were habituated to a labial first; labial tokens were accepted as instances of coronals, but not vice versa. The authors attributed the results to an early language-independent general bias resulting from the acoustic salience of the labial sound. Nam & Polka (2013) conducted a similar study with French and English 4-5 month-olds, who were tested on the same native nonsense syllables /bas/ and /vas/. Infants noticed the switch when the habituated fricative changed to a stop but not when the habituated stop changed to a fricative. Nam & Polka (2013) interpret the results as an extension of the NRV framework to consonants: The perceptual salience of stops allows them to function as referent phones, inducing directional asymmetry. Note that in these studies the contrasts for which asymmetry was found were native contrasts and as a result perceptual narrowing or loss of the ability to discriminate them was not an issue. All except Alvater-Mackensen & Fikkert (2010) were also conducted at an age when the exposure to native language has not caused perceptual reorganization that leads to decline in non-native speech discrimination. However, this kind of asymmetry within the native language is not relevant to the study presented in the thesis; the present study aimed to test possible asymmetry in non-native consonant perception, i.e., in perception of a consonant contrast that does not play a functional role in the naïve language inventory.

Two studies have reported asymmetries in non-native consonant perception, but with conflicting results. Kuhl et al. (2006) reported asymmetries for 6-8- and 10-12-month- old American and Japanese infants in response to /la/ – /ra/ stimuli. The study found a directional asymmetry *regardless of age or language experience*: Infants found it easier to detect a stimulus change from /la/ to /ra/ than the reverse. The asymmetry in this study was attributed to an inborn bias in perception, such as depicted in Polka & Bohn's Natural Referent Vowel (NRV) model (2011). In contrast, in Segal, Hejli-Assi & Kishon-Rabin (2016) consonant asymmetry was found to be dependent on *both age and native language*. Segal and her colleagues tested the discrimination of the voicing contrast /ba/-/pa/ in Arabic-learning infants (whose native language has /b/ but not /p/) and Hebrew-learning infants (whose native language includes a phonological contrast between /p/ and /b/) at 4-6 and 10-12 months of age. The Hebrew-learning infants discriminated the contrast at both ages; no directional asymmetry was observed. On the other hand, there was a decrease in perception of the non-native contrast by the Arabic-learning children between 4-6 and 10-12 months of age. In addition, at 10-12 months of age Arabic-learning infants failed to discriminate the change from /ba/ to /pa/ but showed a marginally significant effect for the change from /pa/ to /ba/; no such asymmetries were found at 4-6 months of age. Though the effect in that study was only marginal, its direction was consistent with the predictions of the PAM model and to those of the NLM model in relation to vowels: For the Arabic-learning infants the /pa/ tokens could have been perceived as atypical examples of /ba/, whereas the /ba/ tokens were prototypical exemplars. As a result, when the atypical /pa/ was presented first, the infants discriminated between the two syllable types, but when the order was reversed they did not. The asymmetries reported for consonants are summarized in Table 1.

Table 1 Overview of studies of consonant asymmetries.

Paper	Age	Native language	Lang Tested	Stimuli	Discrimination *	Possible reason for asymmetry
Alvater-Mackensen & Fikkert (2010)	14 months	Dutch	Native	/bas/-/vas/	/vas/ → /bas/	Acoustic salience of stops
Tsuji et al (2015)	4-6 months	Japanese and Dutch	Native	/n/-/m/	/m/ → /n/	Acoustic salience of the labial
Nam & Polka (2013)	4-5 months	French and English	Native	/bas/-/vas/	/vas/ → /bas/	Salience of stops acts as a referent (extension of NRV)
Kuhl et. al. (2006)	6-8 & 10-12 months	Japanese	Non-native	/la/-/ra/	/la/ → /ra/	Acoustic Salience (extension of NRV)
		English	Native			
Segal et. Al. (2016)	4-6 & 10-12 months	Arabic	Non-native	/p/-/b/	/pa/ → /ba/ at 10-12 months	Perceptual magnet effect
		Hebrew	Native		N/A	

**The arrow in the column indicates the stimulus order in which discrimination was successful.*

The present study explores order effects in non-native between-category perception. As discussed earlier in this chapter, many studies have shown that consonant categories have a discriminable internal structure similar to vowels (Miller, 1994; Dahan, Magnuson, Tanenhaus & Hogan, 2001; McMurray, Tanenhaus & Aslin, 2002; Pierhumbert, 2003). If, we accept, then, that infant perception is not as *categorical* as has previously been suggested, could the asymmetries found in vowel perception be found in the case of consonant perception as well? That is, do infants show order effects that might reflect prototypicality? Would infants fail to discriminate a prototypical exemplar from a subsequently presented less prototypical exemplar, but be able to discriminate the same two exemplars when they are presented in the reverse order? And can we find these effects in between category consonant discrimination? In order to test this, English infants (7- 11- and 15-month-olds) and adults from England and Urdu infants (7- and 11-month-olds) and adults from Pakistan were recruited. English participants were tested on a non-native Urdu consonant contrast /tʃ/-/tʃʰ/ and Urdu participants were tested on a non-native English contrast /w/-/v/ (Phonemic in English but allophonic in Urdu). Note that affricates and fricatives have been used in fewer studies as compared to other consonantal contrasts (Eilers & Minife, 1975; Levitt, Jusczyk, Murray & Carden, 1988; Tsao, Liu, Kuhl & Tseng, 2000; Polka, Colantonio & Sundara, 2001; Ting, Smith & Houston, 2006; Johnson & Babel, 2010; Beach et al., 2008), perhaps because several early studies conducted with young infants failed to provide evidence of discrimination of fricatives (Vihman, 1996). Tsao et al. (2006) is an exception; this investigation tested Chinese and English infants on a Mandarin affricate-fricative contrast /tɕʰ/ vs. /ɕ/ and showed discrimination at 6-8 months in both groups. However, no study to date has tested English infants on a contrasting affricate pair.

It is important to note that Urdu infants grow up in a linguistically unique and diverse environment. In Pakistan, apart from Urdu as national language, English holds the status of official language and there are 60 major regional languages spoken (Akram & Mahmood, 2007). Infants are mostly exposed to English, Urdu and one or more regional languages from childhood. Since there is no other study on the perception of multilingual Urdu infants, the important question here is whether infants and adults growing up in an environment, which is linguistically as diverse as Pakistan, show order-effects and prototypicality for non-native consonant contrast comparable to monolingual English infants.

1.4 Research questions

The following research questions were addressed in the present research;

1) Do infants show order effects reflecting prototypicality for between-category non-native consonants, in the same way as vowels, as suggested by Kuhl (1991)?

2) Will infants fail to discriminate a prototypical exemplar from a less prototypical one when the prototypical exemplar is presented in the first instance but show discrimination when the two exemplars are presented in the reverse order?

3) At what age will any order effect for the non-native consonant contrasts be seen?

4) Is it possible to find order effects in adults' discrimination of a non-native consonant contrast, similar to infants?

5) What is the origin of order effects in consonant perception? Are they the result of increased exposure to a given language (Magnet effect) or a product of the inherent acoustic properties?

1.5 Outline of Thesis

The thesis has eight chapters in total. The structure of the thesis is as follows;

Chapter 2: This chapter presents the pilot study conducted on English speaking adults in which they were tested on different word pairs of Urdu to determine which consonant contrast was most difficult for them to discriminate. The study aimed to find out the most difficult contrast to be tested on English infants in Study 1.

Chapter 3*:* This Chapter describes study 1 in detail in which English infants were tested on the Urdu affricate contrast selected from adult pilot. The study was conducted to find out if a) English infants would be able to discriminate a non-native contrast that was extremely difficult for the adult speakers and b) there is a perceptual decline for non-native consonants at the end of first year in infants from English speaking homes. The results of the study showed not only the decline but also possibility of an order effect in the older group of infants. However, the results were only exploratory because of factors such as smaller group size and possibility of false positives due to unplanned post-hoc analysis.

Chapter 4*:* This chapter discusses Study 2 in detail in which larger groups of English infants were recruited to test specifically for the order effects found in Study 1. The results of the study found order effects similar to Study 1.

Chapter 5: This chapter presents Study 3 in which English infants from the older group in Study 2 were tested again at 15 months of age to find out if order effects are maintained after the first year. The results showed asymmetry similar to the one found in Study 2.

Chapter 6: This chapter presents Study 4 which was conducted on infants from Urdu speaking homes on non-native English /w/-/v/ contrast to find out if comparable asymmetries can be observed in infants with a language background other than English. The English /w/-v/ contrast was used as it forms an allophonic contrast (unlike the phonemic contrast used in previous studies) in Urdu. Results from Study 4 showed order effects in Urdu infants regardless of the age (order effects found in both 7-and 11-month-olds for non-native English contrast /w/-/v/).

Chapter 7: This chapter describes Study 5 in detail in which adults from English and Urdu homes were tested on non-native contrast to find out if the asymmetries observed during infancy are maintained till adulthood. Both groups were also tested on a native contrast to compare their discrimination performance for two types of contrasts.

Chapter 8*:* This chapter presents general discussion on the results from studies 1-5. All the questions raised from the previous studies are discussed in detail and the results viewed from a broader perspective to connect them with infant perception in general. The chapter ends with conclusion and suggested researches for future.

Chapter 2: Pilot Testing

Before moving on to Experiment 1 with English infants, English adults were tested with different minimal pairs of Urdu to determine which consonant contrast was most difficult for English speakers to discriminate. As discussed in Chapter 1, the universal perceptual abilities in the first few months allow the infants to successfully discriminate between most of the contrasts in the world's languages. However, the discriminability of all non-native contrasts is not equal. It has been suggested that even for younger group of infants some non-native contrasts are more difficult than others (Werker & Lalonde; 1988). For that reason, I aimed at finding a non-native Urdu consonant pair that was substantially harder than other consonant pairs from the same language.

2.1 Choosing an Urdu contrast for testing with English listeners

In order to choose Urdu minimal pairs to test English adults, the differences between the phonologies of both languages were considered. Urdu phonetic inventory is listed in the table below (Table 2).

Table 2 Urdu Phonetic Inventory

Plosive	p b p^h b^h		t̪ d̪ t̪^{h} d̪^{h}			ʈ ɖ ʈ^h ɖ^h		k g k^h g^h	?	
Affricate					tʃ tʃ^h dʒ dʒ^h					
Nasal	m		n̪			ɳ	ɲ	ŋ		
Fricative		f v		s z	ʃ			χ ɣ	h	q
Approximant				r		ɽ	j			
Lateral Approximant				l		ɭ				

As we can see, the feature of aspiration is found in more than half of Urdu phonemes; Urdu has aspirated stops, affricates, nasals and approximants. In stops, affricates and retroflex consonants aspiration marks phonological contrasts. On the other hand, in English aspiration is predictable, i.e., context determined, and hence a non-distinctive attribute of /p t k/ in certain contexts. Another feature that distinguishes both languages is gemination (phonetic doubling: Kaye, 2005) or phonetic length: Segments can be geminated (long) as opposed to singletons or non-geminated (Matthews 1997). Gemination is very common in Urdu in both aspirated and unaspirated consonants such as /pat.ta/ 'leaf' vs. /paʈ.ʈ^{h}a/ 'muscle' but occurs only marginally in English. Due to these being two prominent differences in the phonologies of Urdu and English, minimal pairs differing in the features of aspiration and gemination were selected.

2.2 Methodology

2.2.1 Subjects

The adult subjects were recruited by sending emails to the post-graduate administrator of various departments across the University of York, which were then forwarded to all native English speakers aged 18+. The researcher also advertised on Facebook and sent messages to friends inviting participants. A total number of twenty adults were recruited for the experiment. All adults were born and brought up in monolingual English speaking homes and were studying at University of York at the time of the experiment. The age of the adult English speakers ranged from 22-26 years (Mean age = 25 years).

2.2.2 Stimuli

The stimuli included 11 Urdu consonant contrasts (differing by the presence or absence of aspiration) and 5 geminate-singleton contrasts; none of these contrasts exists in English (see Table 3). A female native Urdu speaker recorded the stimuli. A total of 44 consonant word pairs (24 'different word pairs' and 20 'same pairs'), representing 16 phonemic contrasts of Urdu, were created. Each of the words was recorded with a carrier sentence 'can you say' (تم یہ بولو). Each word was recorded three times to provide three different tokens of each word.

Table 3 List of Urdu phonemic and geminate-singleton contrasts used in the pilot

Place of articulation	*Aspirate/non-aspirate (initial only)*	*Number of minimal pairs**	*Singleton/geminate (medial only)*	*Number of minimal pairs*
Bilabial	/p/ - /pʰ/	5		
	/b/ - /bʰ/	4		
Dental	/t/ - /tʰ/	3	/t/ - /tː/	1
	/d/ - /dʰ/	3	/d/ - /dː/	1
Post-alveolar	/tʃ/ - /tʃʰ/	6	/tʃ/ - /tʃː/	1
	/dʒ/ - /dʒʰ/	4		
Retroflex	/ʈ/ - /ʈʰ/	3	/ʈ/ - /ʈː/	1
	/ɖ/ - /ɖʰ/	1		
	/ɽ/ - /ɽʰ/	2		
Velar	/k/ - /kʰ/	5	/k/ - /kː/	1
	/g/ - /gʰ/	3		

*** Reports the overall number of both "same" and "different" word pairs for a given contrast.**

2.2.3 Procedure

The adult participants were tested with an AX discrimination task using E-Prime. Each participant was auditorily presented with 44 pairs of Urdu words over sound-cancelling Bose QC-15 headphones and asked to judge whether they were the same or different, beginning with three practice trials. Participants were asked to press a key ('s') to indicate *'same'*, if the two sounds in a pair seemed to be identical, and another key ('d') if the sounds were judged to be *'different'*. The intra-stimulus gap 300 milliseconds and the order of stimuli was randomized. Each word pair was presented once in each of four combinations: AB (word A followed by word B), BA (word B followed by word A), AA (Word A repeated twice) and BB (Word B repeated twice), with no recorded token of any word being used more than once. In the practice trials, the participant was taken to the next pair only when the correct key had been pressed. The test trials then started automatically. As soon as the participants pressed a response key, they were passed on to the next trial. There was no time limit for the response. Participants were tested individually in a quiet computer room.

2.2.4 Results

The number of errors and response times were computed for each minimal pair and then averaged across all pairs of a given phonemic contrast for each participant. The results are summarized in Table 4.

Table 4 Average response time and average proportion of errors made by adult English speakers.

		Average proportion of errors	Average response time
Singleton consonants			
	/p/ - /p^{h}/	0.45 *(SD = 0.35)*	1538 *(SD = 211)*
	/b/ - /b^{h}/	0.18 *(SD= 0.21)*	1425 *(SD = 151)*
	/k/ - /k^{h}/	0.20 *(SD = 0.29)*	1435 *(SD = 101)*
	/g/ - /g^{h}/	0.32 *(SD = 0.33)*	1560 *(SD = 59.58)*
	/t/ - /t^{h}/	0.25 *(SD = 0.23)*	1433 *(SD = 119)*
	/d/ - /d^{h}/	0.35 *(SD = 0.36)*	1388 *(SD = 35.31)*
	/ʈ/ - /ʈ^{h}/	0.20 *(SD = 0.34)*	1435 *(SD = 576)*
	/ɖ/ - /ɖ^{h}/	0.25 *(SD = 0.44)*	1500 *(SD = 480)*
	/tʃ/ - /tʃ^{h}/	**0.75 *(SD = 0.34)***	**1629 *(SD = 221)***
	/dʒ/ - /dʒ^{h}/	0.37 *(SD = 0.35)*	1446 *(SD = 116)*
	/ɾ/ - /ɾ^{h}/	0.05 *(SD = 0.22)*	1584 *(SD = 350)*
Geminates	/t/ - /tː/	0.2 *(SD = 0.41)*	1553 *(SD = 690)*
	/d/ - /dː/	0.05 *(SD = 0.22)*	1522 *(SD = 280)*
	/tʃ/ - /tʃː/	0.1 *(SD = 0.30)*	1497 *(SD = 479)*
	/ʈ/ - /ʈː/	0.05 *(SD = 0.22)*	1437 *(SD =375)*
	/k/ - /kː/	0.1 *(SD = 0.30)*	1405 *(SD = 430)*

As can be seen in Table 4, the voiceless aspirated-unaspirated affricate pair /tʃ/-/tʃ^{h}/ **(in bold)** had the highest proportion of errors and the longest response times. This suggests that this pair was the most difficult for adult English speakers to discriminate. Note that the average proportion of errors for other word pairs range from 0.05 to 0.45 as compared to 0.75 for affricate contrast. This led to many questions: Why was there so much variation in the proportion of errors shown by the English adults? Why for some word pairs (such as /b/-/bʰ/) the average proportion of error was as low as 0.1 and for some (such as the affricate pair /tʃ/-/tʃʰ/) it was as high as 0.75? In order to find out the reason behind such variability and especially for the lowest discrimination score for Urdu affricate pair, a comparative analysis of English and Urdu stops and affricates was carried out in the next section.

2.3 Acoustic comparison of English & Urdu stops and Affricates

To establish the acoustic similarities and differences between the English and Urdu affricates a comparative analysis of the Voice Onset Time (VOT) of English and Urdu voiceless stops and voiceless affricates was conducted. Both Urdu and English contain plosives and affricates. The plosive sounds in English [p t k] (voiceless) and [b d g] (voiced) have a voicing contrast, whereas in Urdu there is an additional contrast of aspiration. More importantly, the Urdu affricate contrast presents a distinction that does not exist in English: Urdu has four affricates, /tʃ/, tʃʰ/, /dʒ/ and /dʒʰ/, distinguished by aspiration and voicing, whereas the English affricates /tʃ/ vs. /dʒ/ are in principle distinguished by voicing only.

2.3.1 Participants

Two adult monolingual English speakers and four adult bilingual Urdu speakers, who were students of University of York (Mean age = 25 years) were recruited for the experiment.

2.3.2 Stimuli

Since, there is no study on the acoustic properties of Urdu consonants and diversity of regional languages/multilingual leads to high variability in dialects with respect to the region, Urdu stops and affricates were recorded by the adult native speakers of Urdu. Twenty tokens of word-initial voiceless bilabial, velar and dental stops, twenty tokens of word-initial voiceless affricate /tʃ/ and twenty tokens of word-initial voiceless aspirated affricate /tʃ^h/ from each of the four native speakers of Urdu were recorded. The VOT for syllable-initial English voiceless stops was taken from Docherty (1992: British English), whereas twenty tokens of word-initial voiceless affricate /tʃ/ were recorded from each of two native speakers of British English. An Urdu carrier sentence 'can you say' (تم یہ بولو) was used before each word (See Table 5 for details of the stimuli recorded).

Table 5 List of words for acoustic comparison (includes word-initial Urdu bilabial, velar and dental stops and Urdu and English affricates recorded for comparison. The N/A indicates that the values for the given English stops were not recorded but taken from a published source.

Place of articulation	*Urdu Words*	*Gloss*	*Meaning*	*English consonant*
Bilabial	**pɑl**	پل	**"moment"**	**N/A**
	pʊr	پُر	**"to fill"**	
	pɪsə	پسہ	**"grinded"**	
	pər	پر	**"feather"**	
	p^{h}ʊr	پھُر	**"disappear"**	
	p^{h}ɑl	پھل	**"fruit"**	
	p^{h}ɪsə	پھسہ	**"squished"**	
Dental	**t̪ɑl**	تل	**"to fry"**	**N/A**
	t̪ɑ:l	تال	**"beat"**	
	t̪ɑk	تک	**"to look"**	
	t̪^{h}ɑ:l	تھال	**"container"**	
	t̪^{h}ɑk	تھک	**"to get tired"**	
Velar	**kɑ:na**	کانا	**"one-eyed"**	**N/A**
	kɑ:l	کال	**"shortage"**	
	kɑ:t	کاٹ	**"to cut"**	
	k^{h}ɑ:na	کھانا	**"food"**	
	k^{h}ɑ:l	کھال	**"skin"**	
	k^{h}ɑ:t	کھاٹ	**"bed"**	
Affricate	**tʃɑ:l**	چال	**"gait"**	**/tʃʊg/**
	tʃʊp	چپ	**"quiet"**	**/tʃʊk/**
	tʃaʊr	چوڑ	**"thief"**	**/tʃa:p/**
	tʃəɽɦə	چڑھا	**"to climb up"**	**/tʃi:z/**
	tʃɑʊntʃ	چونچ	**"peak"**	**/tʃuz/**
	tʃʊ:nə	چونا	**"paint"**	**/tʃi:p/**
	ʧ^{h}ɑʊkrɪ	چھوکری	**"girl"**	
	tʃ^{h}ɑ:l	چھال	**"outer skin"**	
	tʃ^{h}ʊp	چھپ	**"to hide"**	
	tʃ^{h}aʊɽ	چھوڑ	**"to abandon"**	
	tʃu:nə	چھونا		

2.3.3 Method

The adult participants were recorded in a sound proof recording studio. Each participant wore a dPA 4006 Cardioid headset microphone during the recording session. Stimuli were recorded using Adobe Auditions version 5.5 with channel settings Hi-Pass filter 60Hz applied at 6dB/octave. The recording device was PC running Windows 7 with M-Audio 24/96 soundcard. No compression or other equalization was applied to the recordings. After the recording was finished, stimuli was edited on Auditions and saved to University's online server.

2.3.4 Analysis

VOT measures of Urdu bilabial, velar and dental stops and English and Urdu affricates were computed. Measurements were taken of the entire voiceless period. For example for the Urdu word-initial /tʃ^{h}/, the voiceless period included both the fricative energy for [ʃ] and the aspiration portion of /tʃ^{h}/. The onset of VOT was identified as the start of the release burst of /t/, and the offset as the start of periodicity in the following vowel, as indicated by a box in Figure 2.

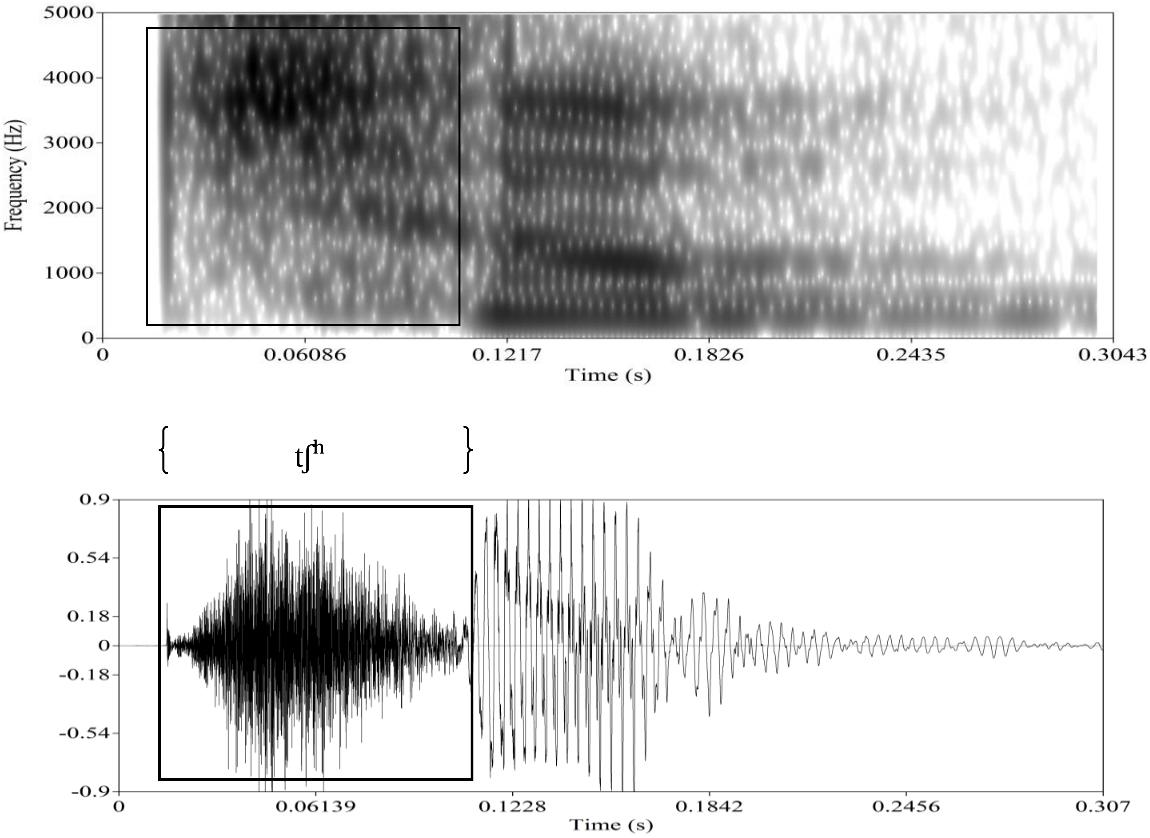

Figure 2 Measurement of VOT of the word-initial Urdu voiceless affricate. The box indicates how the VOT measurement was taken for the affricates. The onset of VOT was identified as the start of the release burst of /t/, and the offset as the start of periodicity in the following vowel in the Urdu word /tʃ^{h}ʊp/.

As shown in Figure 3, the voiceless period for the English /p t k/ is around +14 to +24 ms, for /p^h t^h k^h/ it is around +40 to +60. The voiceless period for the Urdu /p t k/ is around +12 to +18 ms, for /p^h t^h k^h/ it is around +64 to +92. However, the difference between the voiceless periods for voiceless affricates in the two languages is marked. The English voiceless affricate is around +80 ms (minimum: +63 ms, maximum: +102 ms, SD: 12.0), whereas the voiceless period for the Urdu unaspirated affricate is around +80 ms (minimum: +32 ms, maximum: +143 ms, SD:

29.12); for the aspirated Urdu affricate it is around +140 ms (minimum: +96 ms, maximum: +185 ms, SD: 24.34)

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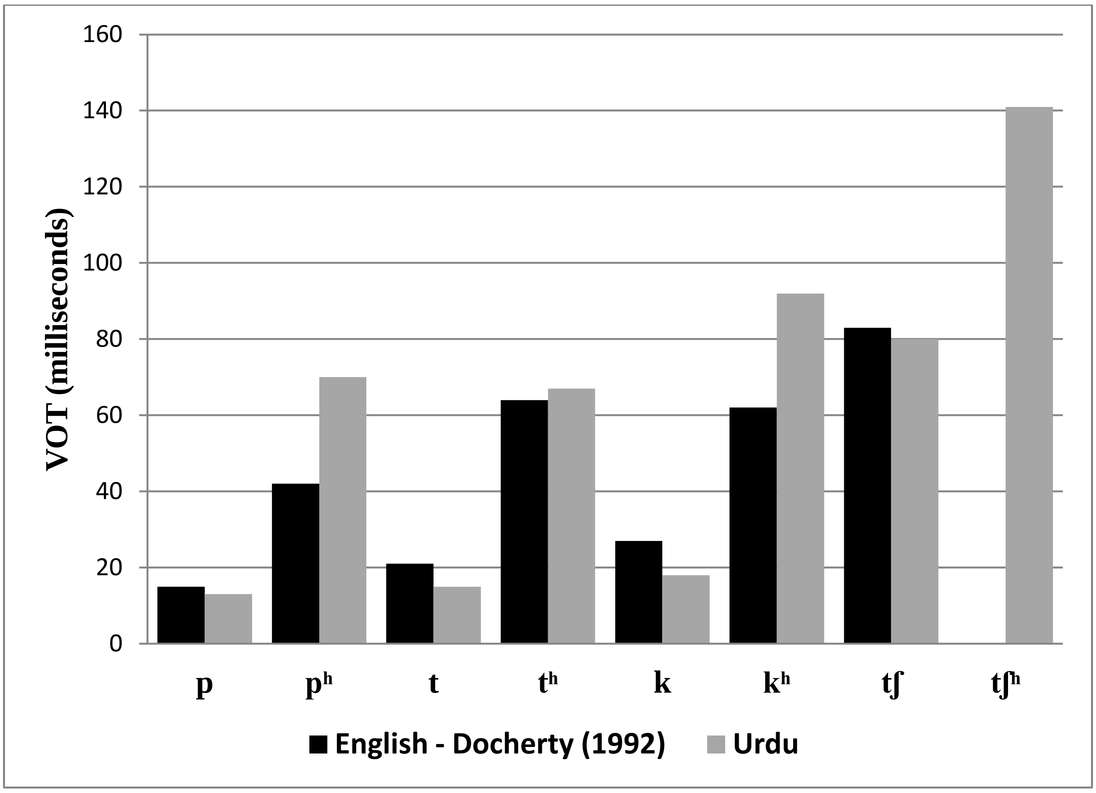

Figure 3 VOT comparison of English and Urdu consonants. Voice Onset Times (ms) of English and Urdu voiceless bilabial, dental, velar stops and unaspirated affricate and Urdu aspirated voiceless affricate. Note that /p t k/ are being used here for English phonologically voiced stops /b d g/.

Please note that although the difference between the VOT values of /tʃ/ and /tʃʰ/ is large, it is a within category difference for English adults. According to Best's (PAM, 1988) it is hard for adult speakers to discriminate any non-native contrast that assimilates to a single category in the native language. During a perception task adult listeners focus primarily on the phonemic level; allophonic status of non-native phonemes is not directly relevant. Non-native phonetic segments are perceptually assimilated to their native phonemes on the basis of the number of shared articulatory-phonetic features. In the case of Urdu /tʃ/ and /tʃʰ/, both non-native phones were most likely perceived as instances of the same native phoneme category /tʃ/, resulting in "single-category" assimilation. Note that large VOT difference between /tʃ/ and /$tʃ^h$/ does not make the discrimination task any easier; in fact it possibly makes it more difficult due to the unfamiliarity of English adults with non-native /$tʃ^h$/.

Chapter 3: Testing English infants on Urdu affricates

After the pilot testing on adults the Urdu affricate contrast /tʃ/ -/tʃʰ/ was selected for testing on the English infants. The studies on the infant perception suggest that it is possible for infants to discriminate most of the speech contrasts found in world's languages. However, many studies have also demonstrated young infants' difficulty in discriminating fricatives (Eilers & Minife, 1975; Levitt et al., 1987; Vihman, 1996; Tsao, Liu, Kuhl, & Tseng, 2000; Polka, Colantonio, & Sundara, 2001; Ting, Smith & Houston, 2006; Johnson & Babel, 2010; Beach et al., 2008). Study 1 was conducted to find out if English infants would be able to discriminate a non-native contrast that was extremely difficult for the adult speakers.

3.1 Research questions - Study 1

Study 1 was conducted with the following research questions in mind;

1) Can the English infants discriminate the aspirated-unaspirated Urdu affricate contrast that is extremely difficult for the adults to discriminate?
2) Is there perceptual narrowing or developmental decline for the non-native affricate contrast in English infants at the end of first year?

3.2 Methodology

3.2.1 Participants: Infants from English speaking homes were recruited through advertisements in a local newspaper. Participants included 7-and 11-month-olds. A total of eight subjects were excluded from the study for the following reasons: fussiness and crying (7), experimenter error (1). The final participant number was as following: 13 seven-month olds (mean age 210 days, range 204-217 days; 7 girls) and 16 eleven-month-olds (mean age 330.6 days, range 322-343 days; 7 girls). Only infants who were full term and without health problems were included in the experiment. All infants were from monolingual English-speaking homes in York, England learning English as their native language. None had any known hearing problem.

3.2.2 Stimuli: Twelve tokens of the words /tʃʊp/ 'quiet' and /tʃ^{h}ʊp/ 'to hide' were recorded in a sound-attenuated recording room by a female native speaker of Urdu. The stimuli were presented to two other native speakers of Urdu for verification. An Urdu carrier sentence 'can you say' (**تم یہ بولو**) was used before each word. Spectograms and waveforms of a single example of each of the recorded Urdu words are shown in comparison with a corresponding English word, *chug* [tʃʊg] (in the Yorkshire accent) in Figures 4 and 5. There is considerable difference in the duration of aspirated and unaspirated affricates (Urdu voiceless aspirated affricate: 328 ms; voiceless unaspirated affricates, Urdu 254 ms, English, 265 ms). Also, the Urdu aspirated affricate in Figure 3 has relatively more intense frication (the affricate portion has been marked with brackets) than the unaspirated affricates of either Urdu (bottom part, Figure 4) or English (Figure 5).

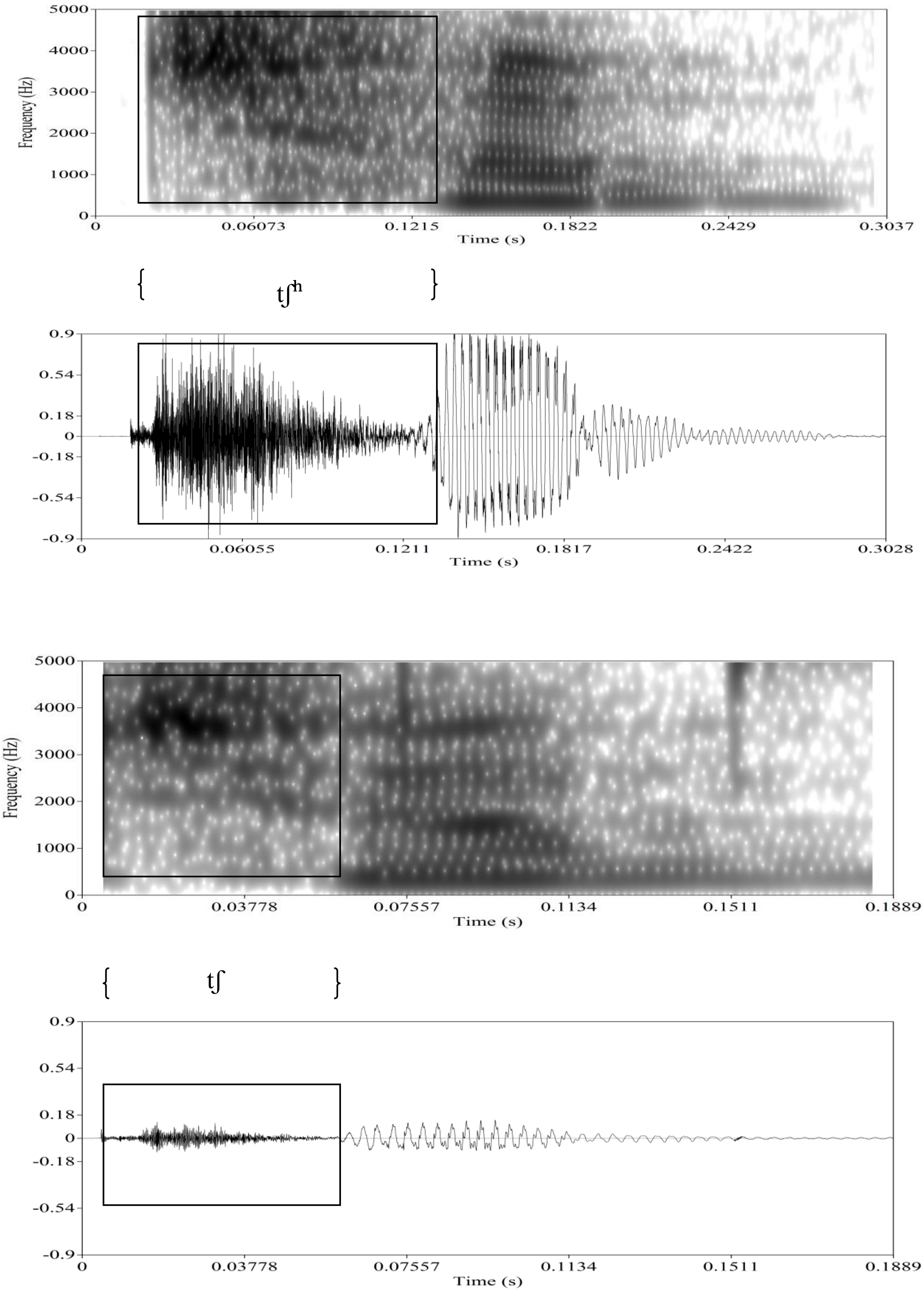

Figure 4 Spectrograms and waveforms of the Urdu affricates used in Study 1, /tʃʰʊp/ top two panels) and /tʃʊp/ (bottom two panels). The affricates are indicated by a box.

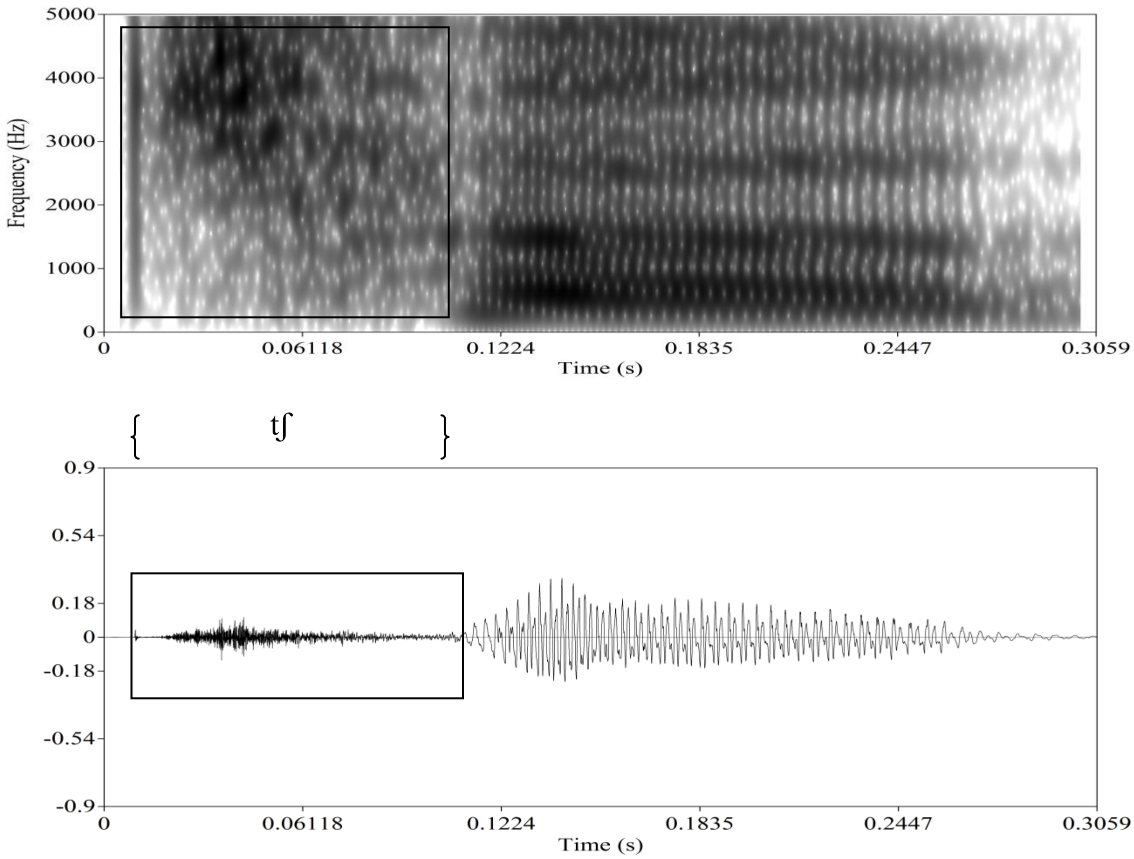

Figure 5 Spectrogram and waveform for English word chug /tʃʊg/. The affricate /tʃ/ is indicated by a box.

All tokens from this first recording were analysed acoustically for maximum amplitude, mean amplitude, mean F0, max F0, min F0, range F0 and duration, using Praat version 5.3.17. T-tests were carried out across all measures. The difference in the duration of tokens of the two words was statistically significant (/tʃ/: M = 0.25; SD = 0.007; /tʃʰ/: M = 0.47; SD = 0.24; t = -21.69; df = 10, $p < 0.05$) as the fricative portion of the aspirated affricates is necessarily longer than that of unaspirated affricates (Harris, Bell-Berti & Raphael, 1995, p. 161); no other significant differences were found. However, since near-significant differences were observed in F0 range between tokens (aspirated affricates had higher F0 values) we recorded another speaker. This second recording was also presented to two other native speakers of Urdu for verification. The analysis of this second recording again revealed near-significant differences for F0 range (/tʃ/ (M = 25.38; SD = 10.60); /tʃ^h (M = 39.45; SD = 39.45); t = -2.14 df = 10, p = 0.07), whereas no statistically significant differences were found for any other acoustic measures except duration. After the second analysis, the near significant difference in F0 between the two minimal pair was attributed to the differences in acoustic properties of the two consonants; Hombert, Ehala & Ewan (1996) have shown that a voiced (vs. voiceless) and aspirated (vs. unaspirated) consonant can cause F0 perturbations by causing a relatively rising F0 contour. Also note that in the voiceless unaspirated affricate of Urdu, shown in the bottom panel of fig. 4, not only the affricate but the following vowel seems to have a much lower intensity as compared to the aspirated affricate shown in the upper panel of fig. 4. The lower intensity seems to affect the whole word in general and this might also suggest the possibility that the speaker was further away from the microphone and the intensity Six tokens of each of the two words that were the most similar acoustically (in maximum amplitude, mean amplitude, mean F0, min F0, max F0, range F0 and duration) to each other were selected from the second recording to be used as stimuli (see Table 6 for acoustic measures).

Table 6 Acoustic measures of the voiceless aspirated/unaspirated affricate contrast /tʃʊp/ - /tʃʰʊp/ used in Study 1 (from the second speaker). The table presents values averaged across the six tokens of each word.

		S1 /tʃʊp/	S2 - /tʃʰʊp/
Max Amplitude (dB)	$\bar{X}$	72.28	72.14
SD		1.56	0.71
Mean Amplitude (dB)	$\bar{X}$	69.61	69.30
SD		1.90	0.77
Mean F0 (Hz)	$\bar{X}$	293.71	293.57
SD		4.35	8.53
Max F0 (Hz)	$\bar{X}$	306.39	313.16
SD		4.05	8.37
Min F0 (Hz)	$\bar{X}$	281.02	281.21
SD		7.71	7.89
Range F0 (Hz)	$\bar{X}$	25.38	31.95
SD		3.89	7.07
Duration (s)	$\bar{X}$	0.25	0.47
SD		0.007	0.02

3.2.3 Apparatus and Procedure

For testing of infants, a habituation-dishabituation visual fixation procedure was employed which uses looking time as a primary tool to measure discrimination in a speech perception task (adapted from Pegg, Werker & McLeod, 1992). The procedure was developed by Horowitz et al., (1972) and it emerged from the idea that infants prefer to look at novel compared to familiar stimuli (Fantz, 1964); animal studies have shown similar responses, with repeated stimulation (Groves & Thompson, 1970). The procedure involves repetitive stimulus presentations to infants while their looking time is recorded. This continues until the looking time is reduced to a pre-fixed criterion (usually 50%) relative to the infant's initial level of looking; this is termed *habituation.* At this stage the test/novel stimulus is presented.

In the test phase, the increase or decrease in the looking time to the novel stimulus is linked to discrimination; increased looking times suggests that infants are able to identify it as a novel stimulus (recovery). This recovery of interest to novel stimuli is typically referred to as *dishabituation* (Groves & Thompson, 1970). No/minimal change in the looking time points towards no discrimination (regression).

Please note that in habituation-dishabituation procedures there is an issue of spontaneous recovery/regression (Oakes, 2010). It has been argued that when using a habituation criterion, looking on the any habituation trial can be low or high as factors other than habituation (such as infants’ processing of the stimuli, detection of novelty, bodily functions and reactions such as sneeze, a phone ringing outside the room and so on) may result in the variations in infants' looking times in any given trial. During an experiment falsely low looking time on the criterion trial/last habituation trial (which can be due to many uncontrollable factors) underestimates infants’ interest to the familiar stimulus, and the higher looking time on the next trial can lead to false novelty effect (or in simpler words give out the false indication that the given infant detected the novel stimulus when in reality he/she did not) (Cohen & Menten, 1981; Bertenthal, Haith, & Campos, 1983; Dannemiller, 1984). Therefore, comparing infants' looking on the last habituation (i.e., criterion) trial to looking to a novel stimulus presented on the next trial may over-estimate infants' dishabituation/recovery process. Oakes (2010) pointed out that in order to be certain that recovery during test reflects a *novelty* preference, many techniques can be used. One is the use of a stringent habituation criterion; a decrease of at least 50%, as a larger decrement may minimize the effect of regression. Other methods include using a window of 2 trials for determining habituation criterion, using infants’ initial looking time as baseline, analyzing only data from infants who met habituation criterion and reporting the time and number of trials that took infants to habituate.[7] All of these techniques have been incorporated in the design to control for spontaneous recovery.

Testing took place in a dimly lit three-sided booth (120 x 122 cm) with black panels in a soundproof room. The stimuli were presented from a Yamaha KX-390 sound player through loudspeakers placed on either side of the booth. The volume was adjusted with the help of a Tenma 72-6635 DP level meter. The infant was seated on the mother's lap approximately 45 inches from the monitor. The mother wore sound-cancelling Bose QC-15 headphones through which multi-talker babble created from the test stimuli was played to mask the auditory stimuli presented to the infants. Mothers also wore earplugs to enhance the masking.

An experimenter sat in the control room outside but adjacent to the soundproof room. Stimulus presentation was controlled by a Mac OSX 10.6.8. A Sony mini DV-HC27 video camera, hidden in the booth, recorded the infant and projected the footage onto a LCD Video Monitor XVIS8 in the control room, from which the experimenter could monitor the infant's looking behavior. To ensure that the acoustic stimuli were completely masked the experimenter wore headphones delivering the same masking sound as used for the parents.

The experiment had two phases; habituation and dishabituation (the methodology for the experiment is diagrammed in Figure 9). Only one stimulus (either /tʃʰʊp/ or

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[7] Another effective way to account for regression is to include a control group in which there is no change in the stimulus to determine/estimate the extent of regression. Due to the extensive nature of data collection and limited time resources inclusion of control group was not possible. Furthermore, since the Babylab in Pakistan was the first of its kind, recruiting willing participants was already a huge challenge. However, I do understand that a control group could have been a better way to control the issue of recovery/regression.

/tʃʊp/) was presented in each phase. Six different tokens of each stimulus were placed on a loop and played repeatedly, in randomized order, in both familiarization and test phases. The sequence of the presentation of the stimuli was counterbalanced so that half of the infants were familiarized with /tʃʊp/, the other half with /tʃʰʊp/. *The assumption was that there will be significant difference in looking times between the habituation and dishabituation phases if English infants are able to identify test stimuli as novel or different from habituation phase. No significant difference in looking times is expected between the two phases if there was no discrimination.* The inter-stimulus interval was 750 ms; other than the inter-stimulus interval there was no break between the habituation and dishabituation phases. The audio segments were presented at approximately 69 dB. Each trial began with a red light flashing on the monitor to attract the infant's attention. When the experimenter judged that the infant was looking at the screen, a key was pressed to deliver the visual stimulus, a black and white checkerboard, to the testing-room monitor. At the same time, the auditory stimuli began playing from the two loudspeakers. Whenever the infant fixated the checkerboard, the experimenter pressed a button, releasing it only when the infant looked away. If the infant looked away for two seconds, the trial ended and a new trial began. Infant looking time was measured for the center look throughout the experiment.

Habituation was defined as two consecutive trials with fixation durations below 50% of the mean of the two highest of the first three trials (Pegg, Werker & McLeod, 1992). This particular habituation criterion was used to control for spontaneous recovery/regression in visual attention. According to Oakes (2010) it is critical to use a habituation criterion that is neither too lenient (resulting in including many infants who habituated by chance) nor too stringent (resulting in excluding many infants who did habituate). For that reason a stringent habituation criteria (at least 50% or below) has been advocated by Cohen (2004) to maximize the number of infants who actually habituate. In addition to that, infants' initial looks as the baseline for habituation criterion were used (Groves & Thompson, 1970; Peterzell, 1993) to maximize the possibility of excluding infants, in the final analysis, who did not actually habituate. When the child reached the planned habituation criterion the computer automatically shifted to the contrasting stimulus for the test phase. Infants were expected to dishabituate in the test trial, showing an increase in looking time to the new stimulus, if they had discriminated the stimulus from the contrasting one presented in the familiarization phase. For infants who failed to discriminate between the habituation and test stimuli no significant change in looking time was expected. Half of the infants listened to /tʃʊp/ in the familiarization phase and /tʃʰʊp/ in the test phase and half heard the stimuli in the reverse order. The experimenter was unaware of the point at which the infant reached the habituation criterion. The number of familiarization trials was not fixed in advance: Different infants received different numbers of familiarization trials, depending upon the time they took to become habituated (with a range of 6-26 trials to habituate). The maximal possible number of trials to habituation was set at 40). The test phase continued until the infant habituated again (following Best, McRoberts and Sithole, 1988; Best et al., 1995; Best and McRoberts, 2003). Maximal trial length was set at 30 seconds. The experimental procedure is summarized in Figure 6 below.

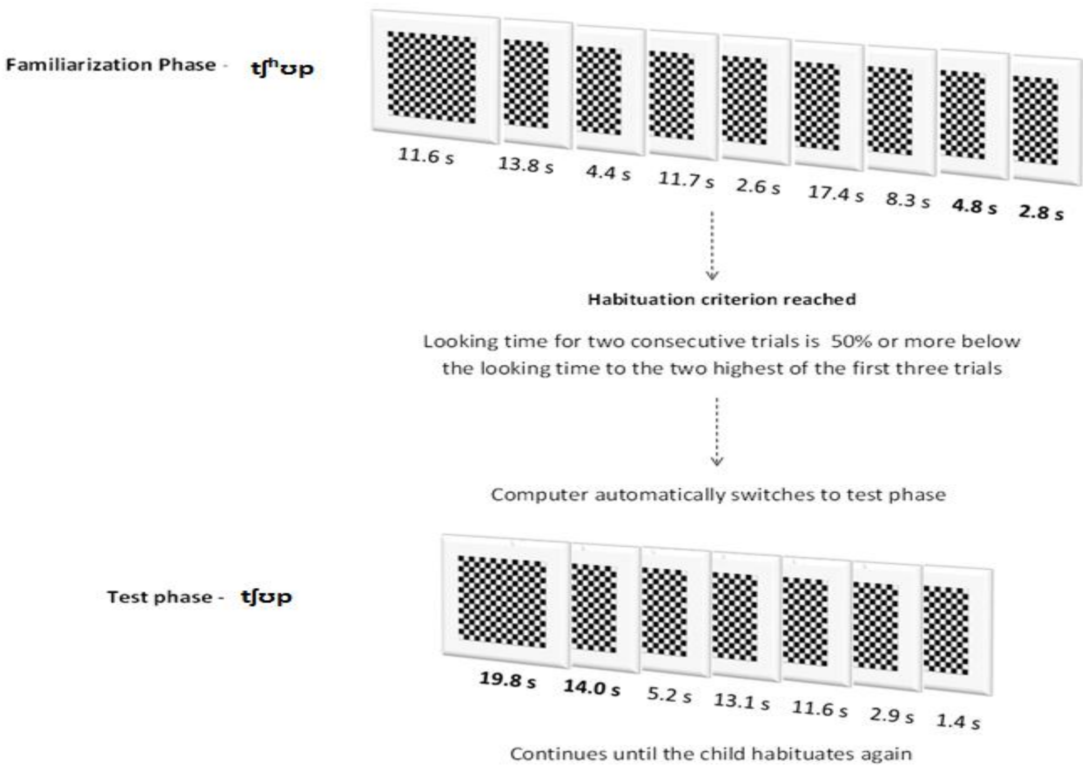

Figure 6 Summary of the habituation procedure used in Study 1. Each square represents a single trial, with time going from left to right. The looking times (in seconds) in the familiarization and test phases are taken from one infant participant for illustrative purposes. The order of presentation of stimuli was reversed for half of the infants. Discrimination was measured by comparing the last two familiarization trials and the first two test trials (in bold font). The infant whose times are shown here did discriminate, as there was a significant increase in looking times in the first two trials of the test phase

3.2.4 Analysis and results from Study 1

Discrimination was assessed by comparing mean looking time over the last two habituation trials (pre-shift phase) to mean looking time over the first two trials of the test phase (post-shift phase). A significant increase in mean looking time during the post-shift relative to the pre-shift phase was taken as evidence that the infant has detected the stimulus change. A discrimination value was calculated to minimize the effect of individual differences in looking times. This involved dividing the mean looking time in the first two test trials by the sum of the mean looking time in the first two test trials plus the mean looking time in the last two habituation trials. The point of no discrimination was set at 0.5 – in other words, equal looking in the two phases. A value over 0.5 indicates that the infant looked more towards the stimuli in the test phase, which signifies discrimination. A value below 0.5 indicates longer looking in the habituation phase, which means that the change was not detected in the test phase. An alpha level of 0.05 was used to determine significance. If the p-value was less than or equal to the alpha ($p < .05$), then the result was considered to be statistically significant. If the p-value was greater than alpha ($p > .05$), then the result was taken to be statistically non-significant (n.s.).

Discrimination values were calculated for each age group (Figure 7). An independent one-tailed t-test was used to analyse difference between the discrimination values of both age groups[8]; No significant difference was found ($t = 1.28$; df = 27; ns). As discussed in chapter 1, differences in discrimination between the two age groups were expected, as a result of perceptual narrowing at the end of first year. However, no significant discrimination differences between the two age groups implied that infants from both age groups showed somehow comparable performance in the discrimination of non-native Urdu contrast. The 7-month-olds' discrimination score was above chance which means that they showed increased looking in response to the test stimuli (M = 0.63; SD = 0.15) and so did 11-month-olds (M = 0.55; SD = 0.16)

[8] Study 1 was designed to look for perceptual narrowing/decline for non-native affricate contrast. Only unidirectional effects were expected for this study. Since any interaction between age and order was not expected, t-test was chosen as a method of analysis over Anova.

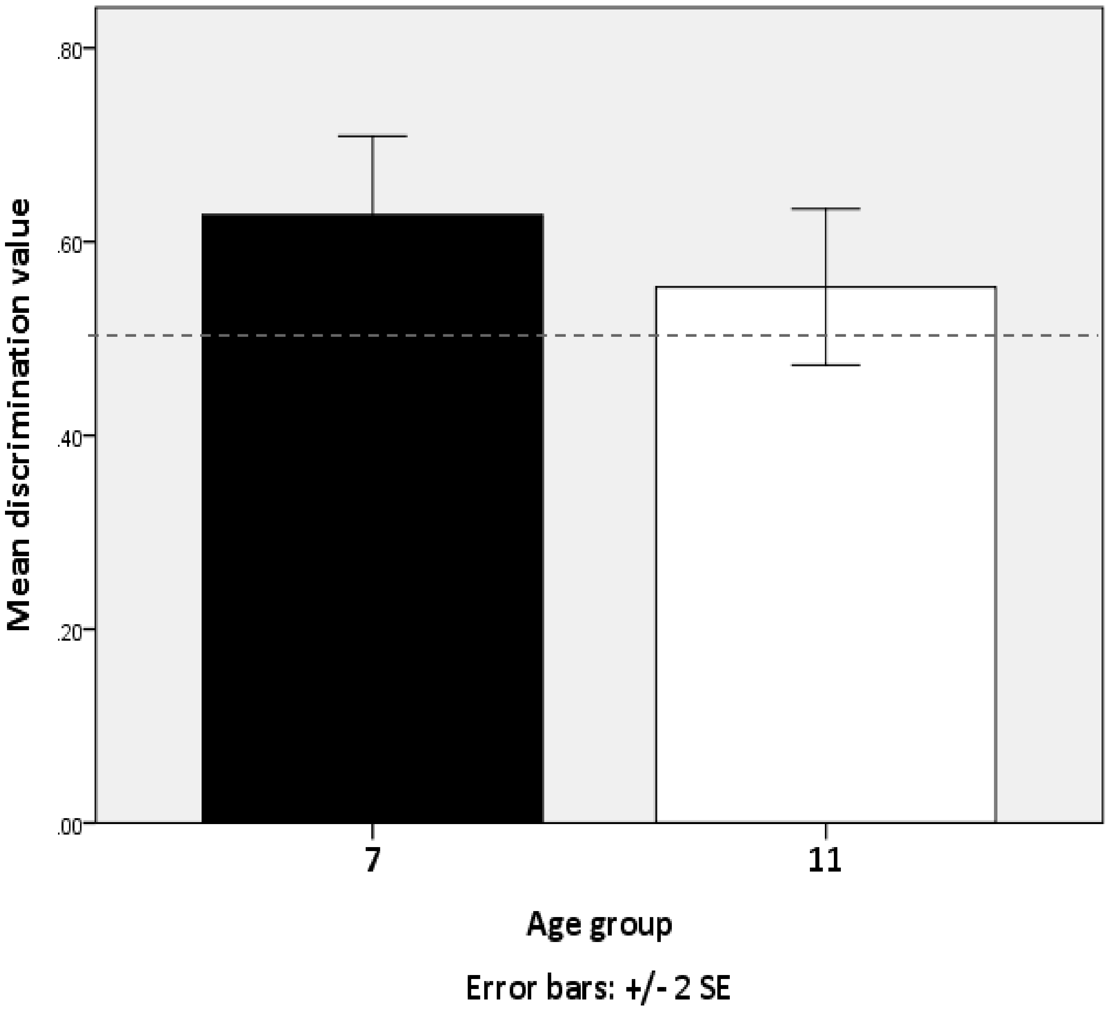

Figure 7 Discrimination values for 7- and 11- month olds in Study 1. The reference line shows the point of no discrimination, 0.5. Error bars: +/- 2 SE.

A closer impressionistic inspection of the mean scores revealed that the discrimination scores of the older group varied with respect to the order; Infants who heard the aspirated affricate first showed a longer looking time for the test stimuli, whereas infants who heard the unaspirated affricate first did not. To further investigate these possible order effects exploratory one-sample 1-tailed t-tests were run on the discrimination scores of the two different orders of both younger and older infants against a maximal no-discrimination value of 0.5[9]. Note, that since

[9] No significant differences in the mean discrimination values of the two groups does not provide sufficient evidence for a lack of perceptual narrowing study 1. It simply shows that the difference is not large, as both the discrimination score of both groups was above 0.5. The main question is not whether older infants are different from younger infants (as tested in this comparison), but about

these were run after the data suggested a possibility of an asymmetry, the significance values calculated for these one-sample t-tests were only used to indicate possible directions for further studies; the results were not taken to indicate significance in the usual sense[10].

In the older group the discrimination value of the infants familiarized on the unaspirated stimulus and then tested on the aspirated stimulus was 0.51 (SD = 0.17); this proved not to be significantly different from chance (t = 0.16; df = 8, ns). The discrimination value for infants with the reverse order of presentation of stimuli was 0.61 (SD = 0.14). Here a significant effect was observed (t = 2.06, df = 6, $p < 0.05$). Among the 7-month-olds, the discrimination value of the infants familiarized on the unaspirated stimulus and tested on the aspirated stimulus was 0.63 (SD = 0.17; t = 2.03; df = 6, $p < 0.05$); the mean discrimination value for the infants familiarized on the aspirated stimulus and tested on the unaspirated stimulus was 0.62 (SD = 0.13; t = 2.31; df = 5; $p < 0.05$). The results indicate that order of presentation of stimuli had no effect on the 7-month-olds (see Figure 8).

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whether younger infants are able to successfully discriminate a contrast that older infants do not. That is why the on-sample t-tests were used that compared each group's discrimination value to 0.5.

[10] I understand that a mean score above 0.5 only shows that the discrimination was above chance and without a control group, the results have to be interpreted with caution. Since the post-hoc analysis was not planned, the results were only exploratory.

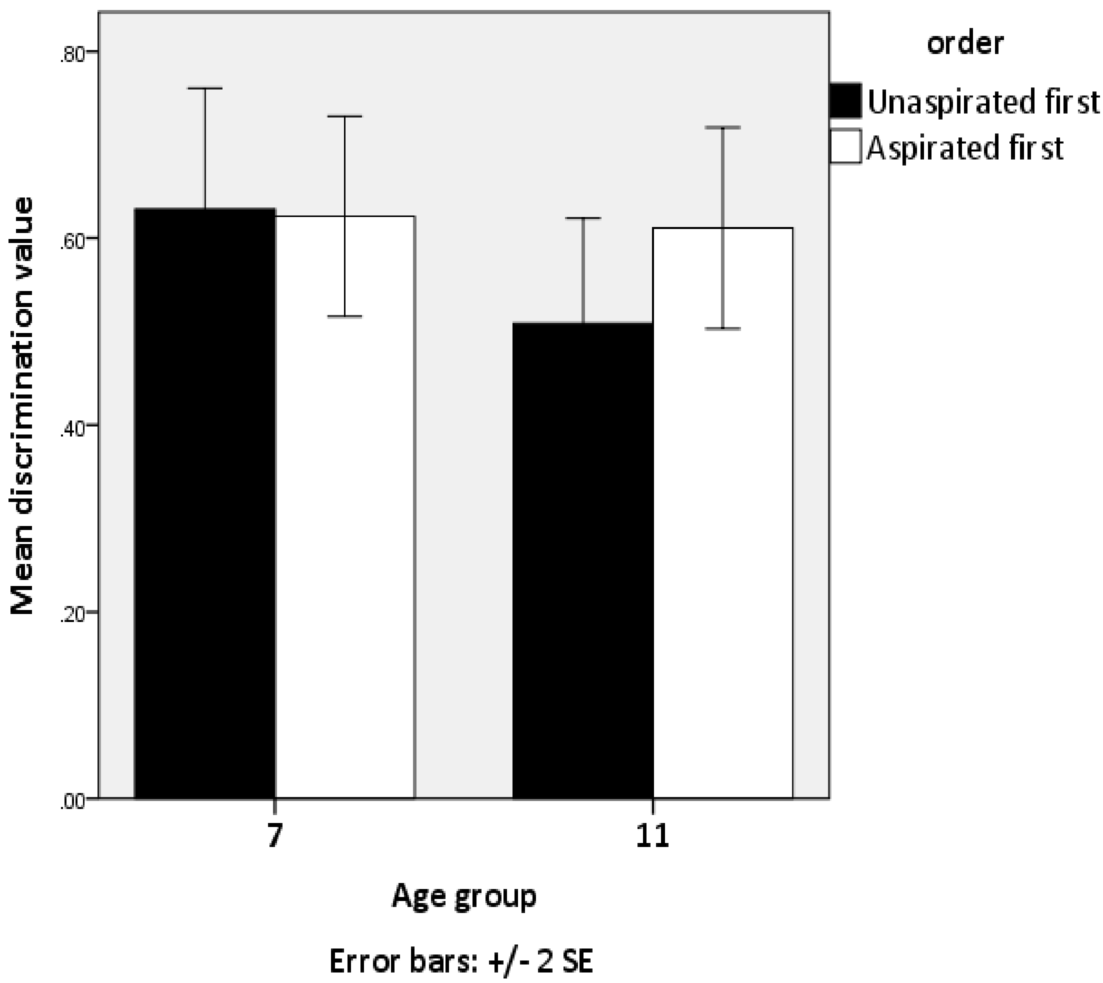

Figure 8 Discrimination values for 7-and 11-month-olds by order of presentation of stimulus in Study 1. Error bars: +/- 2 SE.

In order to ensure that infants' responses to the stimuli in the test phase could be interpreted as a novelty preference and to control the issue of regression/recovery, information about the number of trials infants and the total time required to meet the habituation criterion was analyzed (as suggested by Oakes, 2010). Two 2-tailed t-tests (one for each group) were run to examine whether there were differences in habituation times between conditions[11]. For the 7-month olds there was no significant difference: Mean habituation time to /tʃʰ/ was 111s (SD = 70.62) and to /tʃ/ it was 112s (SD = 48.89, t = -0.04, df = 11, ns). For 11-month-old infants the

[11] Since in study 1 t-tests were used to analyze discrimination values, similar tests were used with habituation times and trials.

mean habituation time to the non-native-like /tʃʰ/ (M = 66s; SD = 24.00) was significantly different from the habituation time to the more native-like /tʃ/ (M = 102s; SD = 33.22, t = -2.39, df = 14, $p < 0.05$). The difference in the number of habituation trials for the two types of stimuli was not significant for either age group: For the 7-month-olds the average number of trials for habituation to /tʃʰ/ was 13 (SD = 8.96) and to /tʃ/ it was 10 (SD = 5.39, t = 0.911, df = 11, ns). For the 11-month-olds the mean number of trials for habituation to /tʃʰ/ was 8 (SD = 2.75) and to /tʃ/ it was 9.11 (SD = 1.96, t = -0.34, df = 14, ns).

3.3 Summary

Study 1 was conducted to explore discrimination of a non-native aspiration contrast in affricates by infants from English-speaking homes. It was found that 7-month-olds successfully discriminated the contrast, whereas the 11-month-olds did not. Order of presentation of the stimuli was not the focus of this experiment. Further exploration of the results showed that order of presentation did not affect the performance of the younger group of infants. However, a potential trend was observed in the older group: Infants showed better performance when the aspirated stimulus /tʃʰʊp/ was presented first. Note that the subgroups tested were small (8 infants habituated to the unaspirated and tested on the aspirated stimuli and 7 infants in the subgroup given the opposite order); asymmetry was not specifically targeted in this experiment and was only investigated after we had already seen the results. The analysis of habituation time between the two orders of presentations in the 11-month-old revealed significant differences within the two subgroups. One possibility can be related to the nature of the stimuli itself. According to Arabin & Straaten (2006), in a habituation experiment habituation is faster to more intense stimulus. With respect to English infants, the aspirated stimulus /tʃʰ/ does not exist in English and thus is a more complex/intense stimulus as compared to the familiar unaspirated stimulus /tʃ/. However, since no such difference was found in the number of habituation trials, no clear conclusion can be reached.

It is significant to mention that the results from study 1 should be interpreted with caution. An unplanned post-hoc analysis was conducted on the subgroups of both ages; additional repeated comparisons increase the possibility of a false positive result (Simmons et al., 2011; Glickman, Rao & Schultz, 2014). Apart from the issue of false positive there was an issue of insufficient sample; the group sizes were selected with only between-group comparisons in mind. For Study 1, 12-16 infants were recruited for each group based on previous studies on infant perception (Werker, 1983, 1984). However, in those studies only between-group comparisons were conducted. The results of Study 1 were therefore only exploratory and were only treated as displaying a possible asymmetry for older group of infants. The p-values for the within-group comparisons were only taken to indicate possible issues which are of interest for further study. Keeping these issues in mind, another study was conducted, with larger subgroups at each age, in order to test specifically for order effects in English infants' discrimination of the non-native Urdu affricate contrast. We expected that, as before, the younger group would show discrimination regardless of order of presentation of the stimuli, whereas the performance of the older group of infants would be affected by the order in which the stimuli are presented.

Chapter 4: Testing English infants for order effects

In the course of Study 1, some intriguing signs of asymmetry were observed in the perception of Urdu affricate contrast. However, due to the small group size, unplanned post-hoc analysis and the risk of false positives no clear conclusion could be drawn. Study 2 was designed to validate the findings of order effect in Study 1 with the help of a larger group size.

4.1 Study 2: Is there an order effect in the discrimination of non-native affricate contrast?

4.1.1 Participants: Thirty 7-month olds (mean age 224 days, range 208-228; 17 girls) and thirty 11-month olds (Mean age 336 days, range 320-340 days; 14 girls) were recruited from English speaking homes through advertisements in the newspapers. Only full-term infants from monolingual homes were included in the experiment.

4.1.2 Stimuli: The same tokens of /tʃʊp/ and /tʃʰʊp/ were used as in Study 1.

4.1.3 Procedure: The procedure was identical to that used in Study 1.

4.1.4 Analysis and Results from Study 2

The results were analyzed for thirty 7-month-olds and thirty 11-month-old infants. Each group included two subgroups of 15 infants who received opposite orders of presentation. An alpha level of 0.05 was used to determine significance. If the p-value was less than or equal to the alpha ($p< .05$), then the result was considered to be statistically significant. If the p-value was greater than alpha ($p > .05$), then the result was taken to be statistically non-significant (n.s.).

An independent two-way ANOVA[12] with age (2 levels: 7, 11 months) and order (2 levels: aspirated-unaspirated, unaspirated-aspirated) as the independent variables was run with discrimination values as the dependent variable. The main effect of age was not significant (df = 1; $F = 2.98$; ns). The main effect of order was significant (df = 1; $F = 16.36$; $p < 0.001$), with aspirated-unaspirated resulting in significantly higher discrimination values (M = 0.70; SD = 0.95) than unaspirated-aspirated (M = 0.59; SD =0.14). The interaction between age and order was also significant (df = 1; $F = 10.49$; $p < 0.01$). An analysis of simple effects[13] showed that difference in the mean discrimination values within the two orders was significant for 11-month-olds (df = 1; $F = 26.53$; $p < 0.001$) but not for the 7-month-olds (df = 1; F = 0.32; $p = 0.57$). Thus, both orders were discriminated equally by the 7-month-olds (M = 0.68; SD = 0.79 for asp-unasp and M = 0.66; SD = 0.86 for unasp-asp) but 11-month-olds discriminated much better when the order was asp-unasp (M = 0.72; SD = 0.10 for asp-unasp and M = 0.52; SD = 0.15 for unasp-asp): Therefore, the infants in the older group differed in their ability to discriminate the stimuli with regards to the order. The results are presented in Figure 9[14].

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[12] Anova was used in Study 2 because this study was specifically conducted to explore the interaction between age and order.
[13] The analysis of simple effects is useful when Anova analysis predicts interaction; testing the significance of simple effects under these circumstances helps to establish the nature of interaction (Keppel & Wickins, 2004). Since a significant interaction was found between age and order, simple effects analysis was run, as suggested by Field (2009, 2013) as a follow-up post-hoc test after two-way Anova.
[14] Line graph was used as it is preferred over bar charts for plotting/representing interaction between variables (Field, 2013).

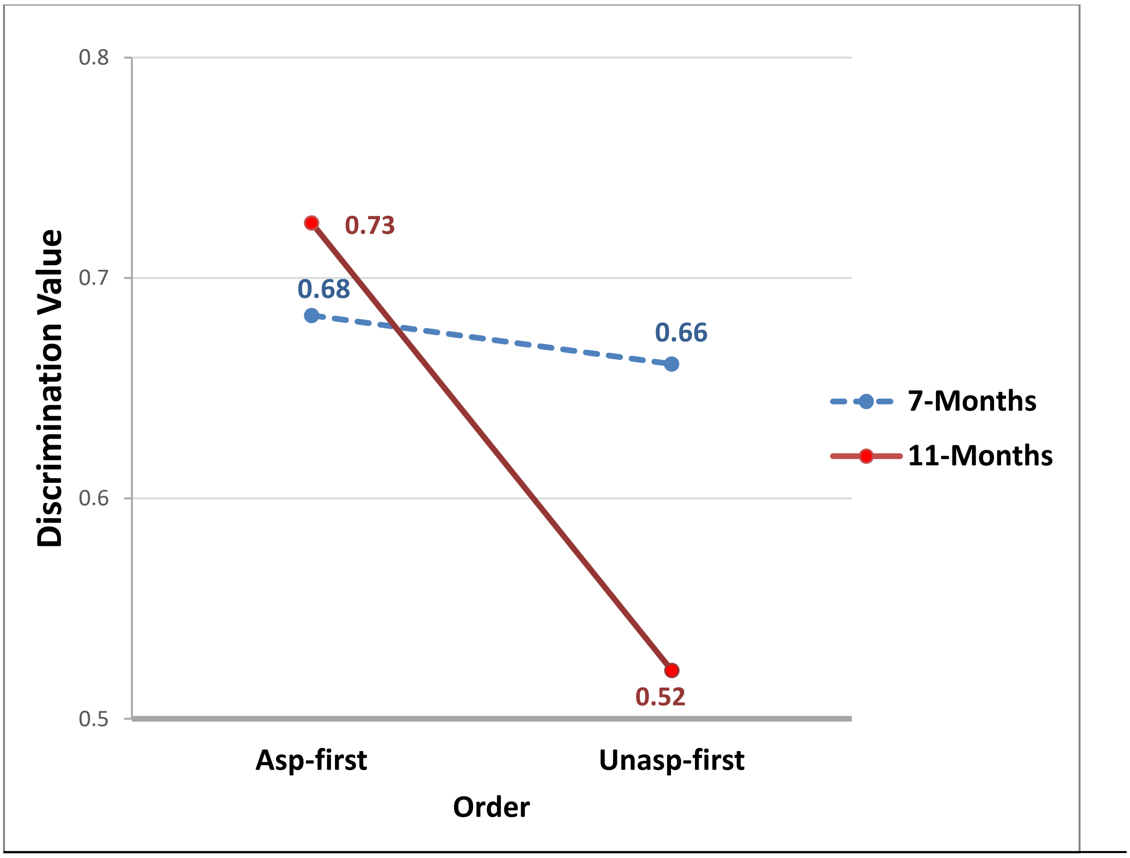

Figure 9 Discrimination values of 7- and 11-month olds by order of presentation of stimulus in Study 2

Next, the differences in habituation times and number of trials were examined for Study 2. An independent two-way ANOVA with age (2 levels: 7, 11 months) and order (2 levels: aspirated-unaspirated, unaspirated-aspirated) as the independent variables was run with habituation times as the dependent variable. The main effects of age and order were not significant (Age: df = 1; F = 0.63; ns; Order: df = 1; F = 1.11; ns). The interaction between age and order was also not significant (df = 1; F = 0.007; ns). Another independent two-way ANOVA with age (2 levels: 7, 11 months) and order (2 levels: aspirated-unaspirated, unaspirated-aspirated) as the independent variables was run with habituation trials as the dependent variable. The main effects of age and order were not significant (Age: df = 1; F = 0.003; ns; Order: df = 1; F = 0.07; ns). The interaction between age and order was also not significant (df = 1; F =

0.50; ns). Thus, no significant differences were found in the habituation times and trials between the two orders for both age groups.

4.2 Summary

Study 2 was conducted to explore the discrimination of a non-native aspiration contrast in affricates by infants from English-speaking homes. Unlike Segal et al. (2015), who found only a non-significant tendency, Study 2 found a significant interaction between order and age. The order of presentation of the stimuli did not affect the performance of the younger group of infants. However, an order effect was found in the 11-month-olds such that discrimination was significantly better when the aspirated stimulus /tʃʰʊp/ was presented first. This suggests that the ability to distinguish non-native sounds had not been lost in the older infants. At the end of first year infants tend to show a decline in the perception of non-native contrasts that are not functional in the ambient language. These results for order effects do not rule out perceptual narrowing at the end of first year; the order effects in 11-month-olds but *not* in 7-month-olds show that there had been a decline in the perception of non-native stimuli, which could only be discriminated in a particular order. However, if at the end of first year infants *can* show discrimination for the non-native contrast, without special training, when presented with the stimuli in a specific order, what about older infants? Can the order effects be found in infants in the second year? To answer these questions infants were tested again at 15 months of age to test if the order effects are maintained after the first year.

Chapter 5: Follow-up Study of English infants in Study 2

The results of Study 2 provided evidence for the order effects in the older English infants; the 11-month-olds behaved similarly to the 7-month-olds when stimuli were presented in the direction of /tʃʰʊp/-/tʃʊp/. As a follow-up, the older infants from Study 2 were tested again at 15 months of age to see if the order effects were maintained after the first year.

5.1 Research questions - Study 3

The following research questions were addressed in Study 3;

1. Is there decline in perception for the non-native Urdu contrast in English after the first year?
2. Do English infants show order effect in the discrimination of non-native affricate contrast at 15-months?

5.2 Study 3: Is the order effect for the VOT contrast maintained after the first year?

5.2.1 Participants: The thirty 15-month olds (mean age 465 days, range 435-470) from English speaking homes who were tested at 11 months of age in Study 1 were tested again at 15 months of age. Two infants were taken out of the analysis for a) crying and b) family relocating to a different city.

5.2.2 Stimuli: Twelve tokens each of the words /tʃa:l/ ‘gait’ and /tʃʰa:l/[15] ‘outer skin’ were recorded in a sound-attenuated recording room by a female native speakers of

[15] The stimuli were changed for Study 3 because previous studies with babies in our York Babylab showed that familiarity with a stimuli affect the discrimination score; the babies remembered a given stimulus after initial exposure and if tested again with the same stimulus they were not able to respond to it in the same way as babies who have never been exposed to it.

Urdu. The stimuli were presented to two other native speakers of Urdu for verification. An Urdu carrier sentence ‘can you say’ (تم یہ بولو) was used before each word. All tokens from this first recording were analysed acoustically for maximum amplitude, mean amplitude, mean F0, max F0, min F0, range F0 and duration, using Praat version 5.3.17. T-tests were carried out across all measures. Again, the difference in the duration of tokens of the two words was statistically significant (M = 0.63 for /tʃ/ and M = 0.55 for /tʃʰ/; df = 22; t = 15.95; p < 0.05); no other significant differences were found. Six tokens of each of the two words that were the most similar acoustically (in maximum amplitude, mean amplitude, mean F0, pitch range, F0 and duration) to each other were selected from the recording to be used as stimuli (see Table 7).

Table 7 Acoustic measures of voiceless aspirated- unaspirated affricate contrast /tʃa:l/-/tʃʰa:l/ used in Study 3. (The table presents values averaged across six tokens of each word).

		S1 - /tʃa:l/	*S2 - /tʃʰa:l/*
Max Amplitude (dB)	$\bar{x}$	75.99	76.13
SD		3.09	2.50
Mean Amplitude (dB)	$\bar{x}$	69.52	70.35
SD		1.98	1.90
Mean F0 (Hz)	$\bar{x}$	199.63	197.63
SD		7.70	3.76
Max F0 (Hz)	$\bar{x}$	263.44	262.55
SD		5.94	4.20
Min F0 (Hz)	$\bar{x}$	113.56	116.56
SD		2.78	2.90
Range F0 (Hz)	$\bar{x}$	149.88	145.95
SD		7.38	6.09
Duration (s)	$\bar{x}$	0.64	0.55
SD		0.01	0.02

5.2.3 Procedure: The procedure was identical to that used in Study 1 & 2.

5.2.4 Analysis and results from Study 3

The results were analyzed for twenty-eight 15-month-old infants. The group included two subgroups of 14 infants, who received opposite orders of presentation. Each subgroup received the stimuli in the same order as infants in Study 2 at 11 months. An independent two-tailed t-test showed a significant difference between the discrimination values of the two subgroups (t = -2.63; df = 26; p < 0.05). As the results show, an asymmetry was observed in the performance of the subgroups. Infants who listened to the stimuli in the direction of aspirated first discriminated better than the other subgroup with reverse order. The discrimination values of the subgroups are summarized in Figure 10.

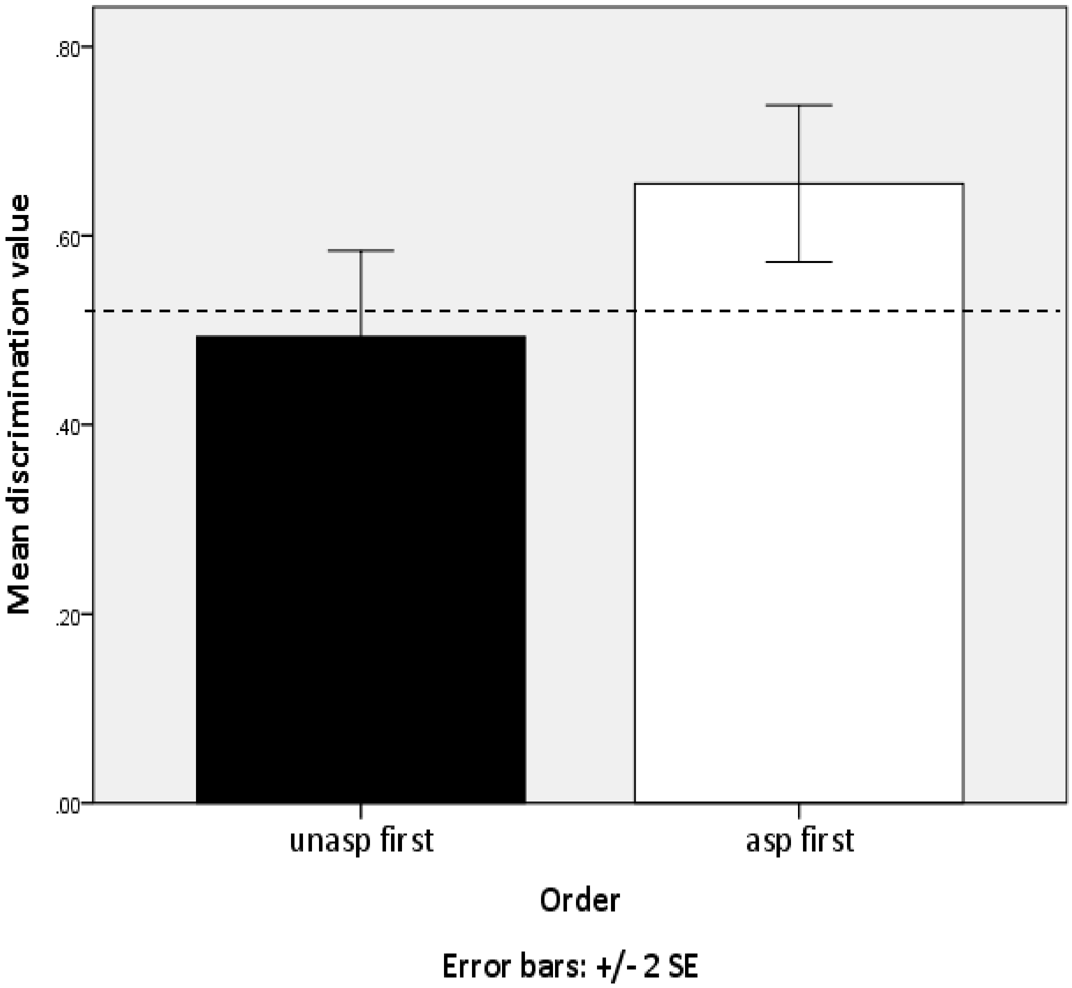

Figure 10 Discrimination values for 15-month olds in Study 3. The reference line shows the point of no discrimination, 0.5. Error bars: +/- 2 SE.

A two-tailed t-test[16] run to examine whether there were differences in habituation times between conditions was not significant (mean habituation time to /tʃ/: 120s, SD = 60.37; /tʃʰ/: 89s, SD = 45.48; df = 26; *t* = -1.55, ns). The difference in the number of habituation trials for the two subgroups was also not significant (mean number of trials for /tʃ/: 10; SD = 3.05; /tʃʰ/: 8; SD = 3.62; df = 26; *t* = -1.24, ns). This means there was no difference in habituation times or trials within the two orders that could have affected the discrimination score.

[16] As a t-test was used to analyse discrimination scores in Study 3, similar test was used for analyzing habituation times and trials.

5.3 Summary

Study 3 was conducted to test if the English infants tested in Study 2 show comparable asymmetry at 15 months of age for non-native Urdu affricate contrast. The results showed order effects in English infants' discrimination of non-native Urdu affricate contrast even at 15 months of age. Perceptual decline was only observed when the non-native Urdu stimuli were presented in the direction of /tʃʊp/-/tʃʰʊp/. This showed that infants still remained capable of discriminating a non-native affricate contrast after the first year when presented in a particular order.

Note that no difference in habituation time or in number of trials to habituation between infants exposed to the two different orders in either age group was found in either Study 2 or Study 3. This not only suggests that no affricate in the pair was inherently easier or harder to habituate to for English infants but also that the significant difference in habituation times for 11-month-olds in Study 1 was likely by chance. Also, no difference in habituation time or number of trials was found in the 7-month-old groups in all three studies. This suggests that asymmetry observed in study 2 & 3 in the discrimination of the non-native Urdu affricates is unlikely to be the result of one affricate being inherently, or acoustically, more attention-grabbing and therefore slower to lead to habituation. So far the following has been established in the light of studies 1-3;

1. 7-month-olds infants successfully discriminated the Urdu affricate contrast irrespective of the order.
2. The 11-month-olds showed an order effect for the perception of non-native Urdu contrast: Discrimination was only observed when the stimuli are presented in the /tʃʰʊp/-/tʃʊp/ order.

3. The order effects for the non-native Urdu contrast were still there when the older infants were tested again at 15 months of age.

Study 3 raised many questions: If infants still showed order effects at 15 months of age for the non-native Urdu contrast, when is this asymmetry likely to disappear? What role does stimulus type play in this regard? Can we get comparable results with different stimuli? For English infants, the Urdu affricate contrast does not exist in English but can similar results be found with an allophonic contrast? How do infants process a non-native phonemic pair that forms allophonic contrast in the native language? Studies have shown that being segments of different phonemes is not sufficient for sounds to be discriminable (e.g., [t], the unaspirated /t/ that occurs after /s/, and [d̥], the voiceless /d/, although from different phonemic categories in English, /t/ and /d/, are difficult to discriminate due to acoustic similarity; Pegg & Werker, 1997); also there is reduction in attention to even native allophonic contrasts by as early as 11 months (Seidl, Cristia, Bernard & Onishi, 2009). Many studies have demonstrated that adults process phonemic contrasts more efficiently than allophonic ones; poor and slower discrimination is shown by adults for the allophones of the same phoneme than between two different phonemes (Boomershine, Hall, Hume, & Johnson, 2008; Whalen, Best, & Irwin, 1997). The important question to ask in this regard is whether it is possible to find similar asymmetry in the discrimination of a non-native phonemic contrast that is allophonic in the native language. Also what about infants from a different language background? Can similar order effects be found in infants whose native language is not English? In order to find out how general these order effects were, infants from Urdu speaking homes were recruited and tested on non-native English stimuli (Phonemic in English but allophonic in Urdu) for comparison.

Chapter 6: Testing Urdu infants on English Stimuli

In Study 4, Urdu infants were tested on non-native English /w/-/v/ contrast to investigate how Urdu infants respond to this English phonemic contrast that is allophonic in their native language. For the first step, recordings from a female native speaker of Urdu were analysed to understand the [w]-[v] allophony in Urdu before testing the English /w/-/v/ contrast on Urdu infants.

6.1 The [w]-[v] allophony in Urdu

The consonants /w/ and /v/ are distinct phonemes in English, but are in free variation in Urdu (expressed as /v/ in IPA and a single consonant symbol in Urdu orthography [و]). Speakers produce either of the sounds, depending upon frequency of use or personal preference without affecting intelligibility (Kachru, 1987)

However, the allophony of [w] and [v] is a matter of debate. Many linguists are of the view that [v] has been replaced by [w]: The approximant [w] is part of Urdu and the fricative [v] only exists in some highly Persianised Urdu accents (Kachru, 1987). Another opinion is that [v] has replaced the labio-velar approximant [w] in Urdu (Masica, 1993). Pierrehumbert & Nair (1996) carried out an investigation of this [w]-[v] allophony in Hindi[17]. With the help of a dictionary they collected all the prosodic positions of /v/ which comprised of a sample of 154 words. Three native speakers of Hindi were recorded uttering the selected words. The results showed that [v] and [w] were heard for the same consonant only under certain circumstances. In

[17] Urdu and Hindi, despite being spoken in two different regions and having different names and orthography, are essentially the same language, with minor differences in lexicon but similar phonology

other circumstances, only [w] or [v] was heard. According to the results /v/ was rendered as a) [v] at the beginning of a word CV, b) [w] when preceded by a consonant in the same syllable CCV, c) [v] or [w] at the medial position of a word and d) [w] at the medial position if following germination.

Apart from Pierrehumbert & Nair (1996), very little research has been done on natural speech in Urdu[18] to throw light on this problem. There is no clear phonetic description of Urdu anywhere in the literature and it is beyond the scope of this study to do an in-depth phonetic analysis of Urdu. However, in order to understand the [w]-[v] allophony in Urdu for the sake of this thesis, a female native speaker of Urdu was recorded with words of Urdu containing the possible allophones [v] and [w]. On the basis of the analysis from Pierrehumbert and Nair (1996), it was predicted that /v/ would be realized as [v] in the word initial position while [w] would be found either word medially or after a consonant in the same syllable.

6.1.1 Participant:

The subject was a female native speaker of Urdu, 25 years of age and a student at the University of York. The subject had been living in England for five months.

6.1.2 Stimuli:

For recording the stimuli, a list of Urdu words was formulated with the Urdu phoneme /v/ in a) word-initial (CV) position, b) preceded by the word-initial consonant in the same syllable (CCV) and c) syllable initial (CVC.CVC) position paired with /i, ɪ, e, ɛ, ə, a, ʊ, o/ to understand in which context [w] and [v] are produced. Since both the allophones are represented by a single consonant symbol [و] in Urdu, the word list was presented to the native speaker in Urdu script. The

[18] Appendix 5 presents a Phonemic description of Urdu adopted from a book titled 'Hindi Phonology' by Ucida (1977). Urdu and Hindi share similar phonology. For that reason, the description of Hindi phonology in the book applies very well to Urdu.

speaker was given no instruction as to how the consonant should be produced in order to obtain the most natural realization of the consonant. Each word was recorded with a carrier sentence ‘can you say’ (تم یہ بولو) or ‘can you write’ (تم یہ لکھو). Each word was recorded four times to get multiple tokens (list of words is presented in appendix 5). The movement of the lips was also observed by the experimenter. The rounding of the lips was taken to be association with [w], whereas drawing the lower lips away from the upper teeth was taken to be associated with [v].

6.1.3 Method

The female native speaker of Urdu was recorded in a sound proof recording studio. The participant wore a dPA 4006 cardioid headset microphone during the recording session. Stimuli were recorded using Adobe Auditions version 5.5 with channel settings Hi-Pass filter 60Hz applied at 6dB/octave. The recording device was PC running Windows 7 with M-Audio 24/96 soundcard. No compression or other equalization was applied to the recordings. After the recording was finished, stimuli was edited on Auditions and saved to University’s online server.

6.1.4 Analysis:

The acoustic analysis was carried out on Praat version 5.3.17. The comparison was done analyzing waveforms and spectrograms for following acoustic characteristics; a) frication, b) amplitude, c) voicing , d) manner of articulation and e) periodicity. The analysis of Urdu recordings shows no allophonic variation. The consonant realised in nearly all vowel contexts was the labio-dental approximant [ʋ]. While producing this labio-dental approximant, the lower lips and teeth were held in a position similar to English /v/. In a standard phonetic labio-dental fricative the lower lip touches the upper teeth, producing a closure tight enough to produce frication. In the production of this consonant in Urdu, the upper teeth touched the lower lips (lips stayed almost stable). Most importantly, the contact between the lower lip and the teeth was weak: The closure was caused by teeth touching the inside of the lower lip lightly. Because of the weak contact in the production of the consonant, the frication was lost and the consonant was rendered as [ʋ] instead of [v]. Figure 11 presents the spectrogram and waveform for Urdu labio-dental approximant [ʋ]. The formants are clearly visible in the spectrogram and the waveform shows periodicity.

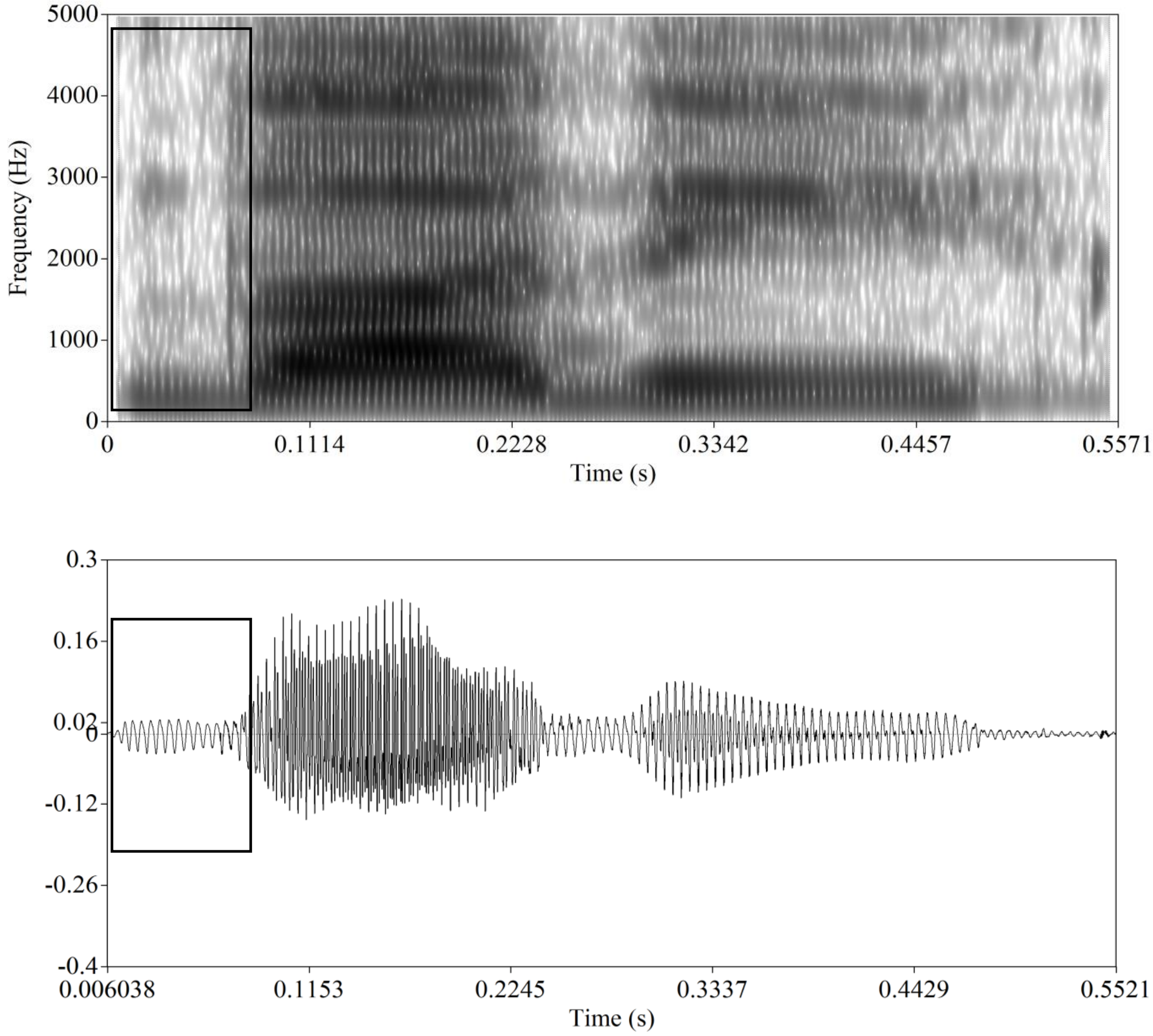

Figure 11 Spectogram and waveform for the Urdu word [ʋa:di]. The labio-dental approximant is indicated by the box.

In some of the words, the consonant sound started with a wider articulation which became narrow because of the strong contact of the two articulators (shown in Figure 12). We can see in the spectrogram that the consonant started as a [ʋ] but around 0.03 there was frication that followed through till the start of the following vowel. This gave rise to an articulation similar to [ʋ͡v]. This labio-dental approximant was produced with a closer, much tighter, articulation, which gave a percept of frication.

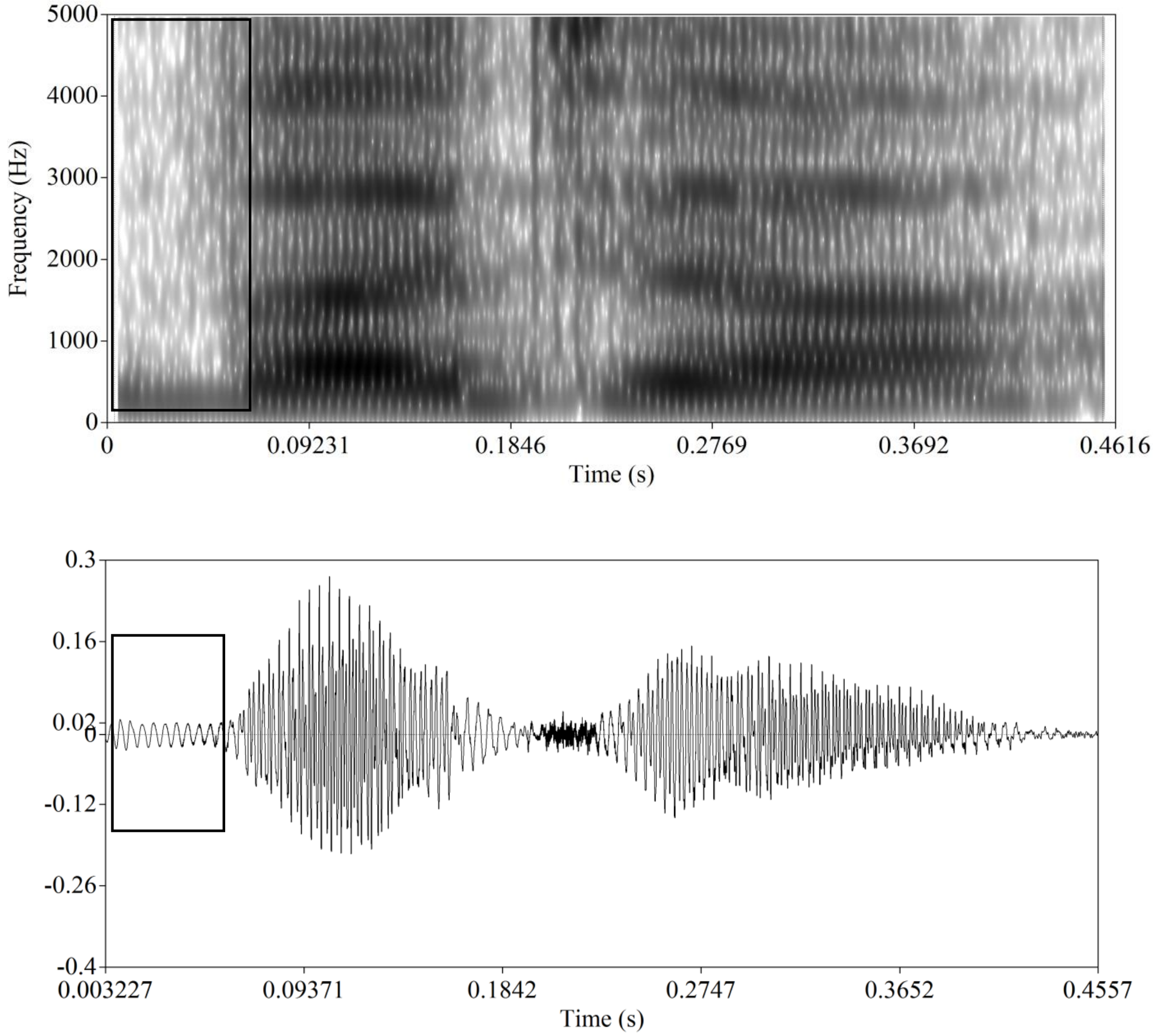

Figure 12 Spectrogram and waveform for the Urdu word [ʋadʒə]. The labio-dental approximant is indicated by a box.

The Urdu consonant was realised like a fricative in one of the tokens of the same word [ʋadʒə] (shown in Figure 13). Around 0.02 the frication started and lasted throughout, until the following vowel. Here the consonant looked more like a voiced labio-dental fricative [v] than a labio-dental approximant [ʋ]. The strong contact between the two articulators resulted in frication. However the frication was not as intense as a standard phonetic fricative such as English /v/, shown in Figure 13.

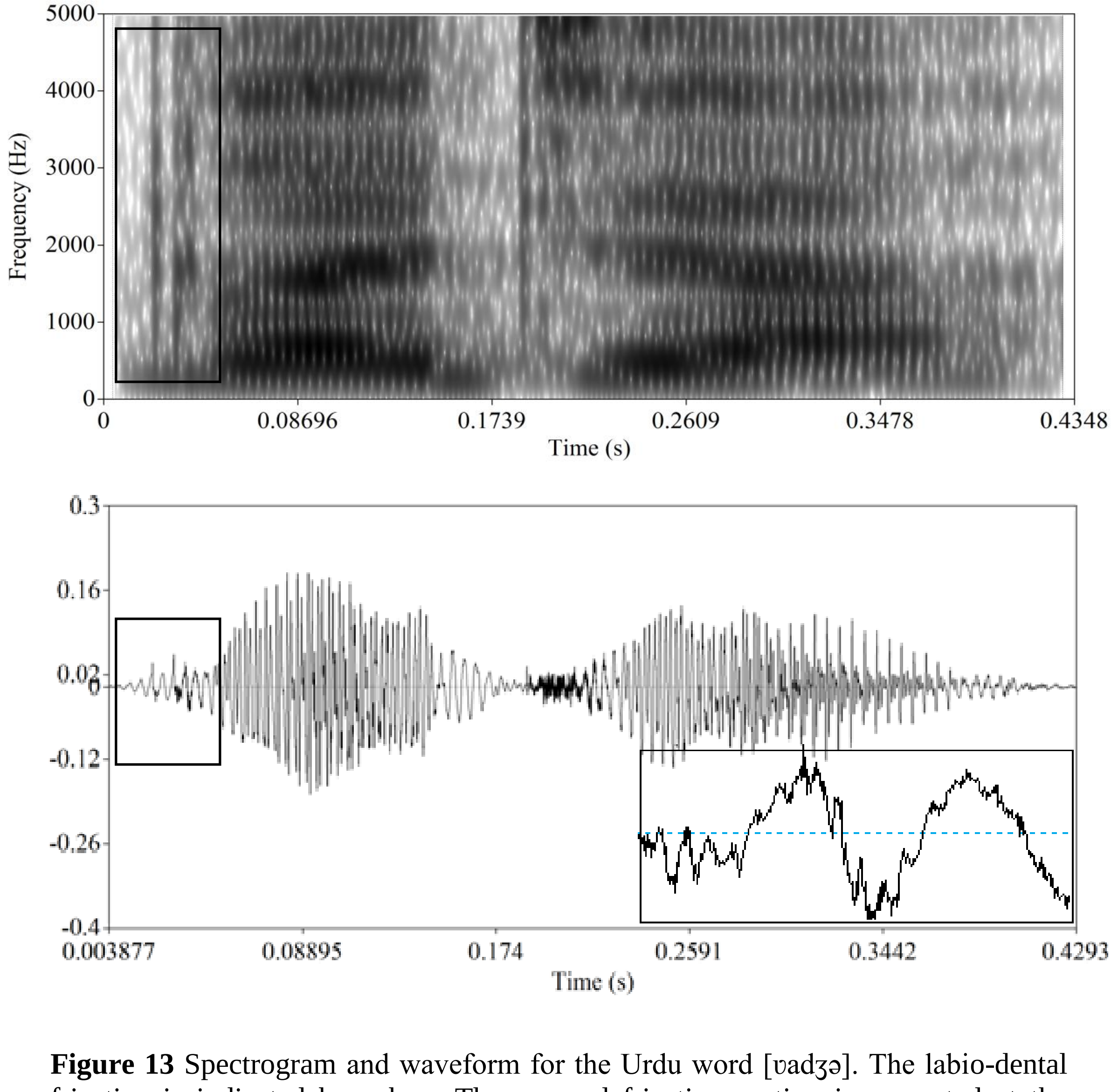

Figure 13 Spectrogram and waveform for the Urdu word [ʋadʒə]. The labio-dental fricative is indicated by a box. The zoomed fricative portion is presented at the bottom right.

In summary, it looks like there is no allophonic variation in Urdu. The [ʋ] has replaced both [v] and [w]. In the production of some tokens of [ʋ], the consonant produced was closer to [v] as a result of the strong contact of the articulators. No lip rounding was found in any of the tokens: The loss of lip rounding seems to have resulted in the loss of the labio-velar approximant [w]. Future investigations should look into this allophony with the help of a detailed instrumental study and in-detail phonetic investigation.

The results from the present analysis are not intended to contradict the findings of Pierrehumbert & Nair (1996). There can be many reasons why the results from current analysis are different from those earlier findings. In P&N's study three speakers of Hindi were used, whereas this analysis used recordings from a single native speaker of Urdu. There is a possibility that the results from this native speaker of Urdu do not reflect the general language behaviour of the large community of Urdu speakers (or are exceptional, for some reason). As noted in the first chapter, Pakistan is a diverse multilingual community: This makes the native speakers susceptible to regional or dialectal differences. Pakistan has a total population of 186 million; roughly 60 languages are spoken over the region (Akram & Mahmood, 2007). The native speaker in the study hailed from Lahore, where Punjabi is the predominant language spoken. The /ʋ/ is part of Punjabi phonetic inventory; the results from the current analysis might have been influenced by the regional language used in the native speaker's hometown. Under the current circumstances all the words used in the recording appeared to have [ʋ], irrespective of their position within a word. The list of words used in the study is given in appendix 5. The phoneme found in the words spoken by the native speaker in the current analysis is used in the IPA transcription of the words in the list.

6.2 Predictions for Study 4

As there seems to be a loss of [w] in Urdu according to the analysis presented in section 7.1, it was expected that order effect would be observed in older group of Urdu infants in the direction of /w/-/v/ (non-native-native), in line with studies 1-3.

6.3 Study 4: Urdu infants on English /w/-/v/ contrast

In Study 4, infants from Urdu-learning homes were tested on a non-native English contrast. Studies 2 and 3 showed order effects in English infants for non-native /tʃʰ/-/tʃ/; this distinction does not exist in English. Study 4 tested infants from Urdu-speaking homes on phonemic English /w/-v/ contrast (allophonic in Urdu) to see if we can find similar evidence for order effects in infants from a different language background with an allophonic contrast.

6.3.1 Research questions - Study 4

The following research questions were designed for Study 4;

1. Do Urdu infants show a decline in the perception of the non-native contrast /w/-/v/ at the end of the first year?
2. Is there an order effect in the perception of the non-native English /w/-/v/ contrast by the Urdu infants?
3. If yes, what is the direction of the asymmetry in Urdu infants for English /w/-/v/?

6.3.2 Participants: Infants were recruited through word of mouth in Islamabad, Pakistan. Participants included thirty seven-month-olds (mean age 214 days, range 210-222 days; 20 girls) and thirty-three 11-month-olds (mean age 333.7 days, range 325-348 days; 22 girls) from Urdu speaking homes. Only infants who were full term and without health problems were included in the experiment. An additional six subjects were excluded for fussiness and crying. All infants were from bilingual homes in Islamabad, Pakistan. None had any known hearing problem[19].

6.3.3 Stimuli: Twelve tokens each of the words /vaɪn/ ‘vine’ and /waɪn/ ‘wine’ were recorded in a sound-attenuated recording room by a female native speaker of English. The stimuli were presented to two other native speakers of English for verification. An English carrier sentence *can you say* was used before each word. Spectograms and waveforms of a single example of each of the recorded English words are shown in Figure 14.

[19] In Pakistan, children are mostly bilingual or multilingual. Children are mostly exposed to English (which is an official language), the national language Urdu and one or two regional languages right from the start. English is used so commonly that there is frequent code-switching in general day-today use. Apart from that, all of the children’s cartoons and books are in English. English is also the main language of most of the day cares.

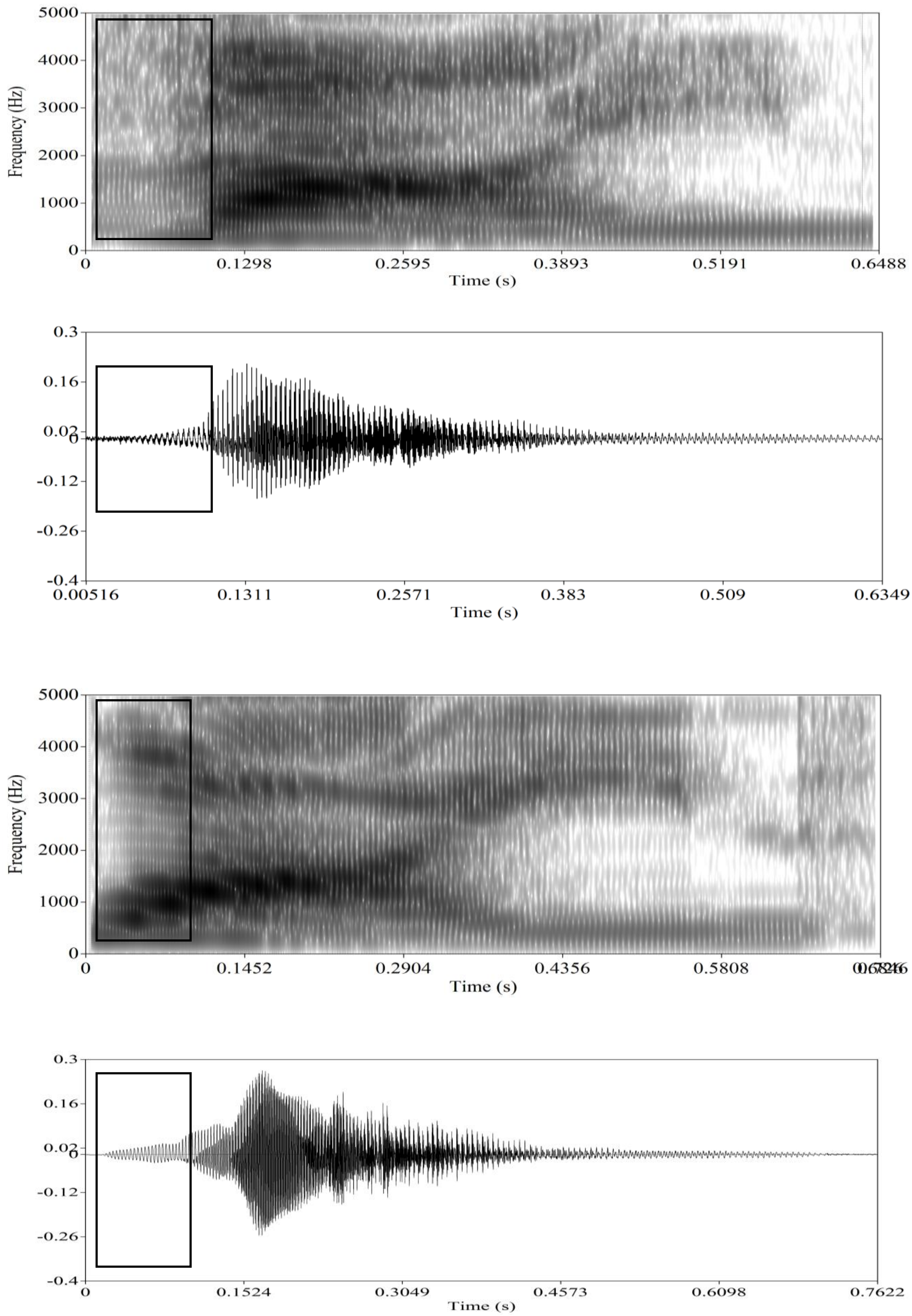

Figure 14 Spectrogram and waveform for English stimuli used in Study 4, (top) English word [vaɪn], (bottom) English word [waɪn]. The labio-dental fricative [v] and the approximant [w] are indicated by a box.

All tokens from this recording were analysed acoustically for maximum amplitude, mean amplitude, mean F0, max F0, min F0, range F0 and duration, using Praat version 5.3.17. T-tests were carried out across all measures. The difference in the duration of tokens of the two words was statistically significant (M = 0.89 for /v/ and M = 0.85 for /w/; df = 22; $t = 4.59$; $p < 0.05$); no other significant differences were found (see Table 8 for acoustic analysis). Six tokens of each of the two words that were the most similar acoustically (in maximum amplitude, mean amplitude, mean F0, max F0, min F0, range F0 and duration) to each other were selected from the recording to be used as stimuli.

Table 8 Acoustic measures of the contrast /waɪn/ - /vaɪn/ used in Study 4. The table presents values averaged across the six tokens of each word.

		S1 - /vaɪn/	S2 - /waɪn/
Max Amplitude (dB)	$\bar{X}$	73.70	75.40
SD		2.10	1.96
Mean Amplitude (dB)	$\bar{X}$	64.09	66.70
SD		1.41	1.86
Mean F0 (Hz)	$\bar{X}$	184.71	184.68
SD		5.26	4.20
Max F0 (Hz)	$\bar{X}$	247.73	249.54
SD		11.26	7.17
Min F0 (Hz)	$\bar{X}$	119.57	114.98
SD		4.64	3.34
Range F0 (Hz)	$\bar{X}$	128.16	134.57
SD		12.34	7.48
Duration (s)	$\bar{X}$	0.90	0.85
SD		0.03	0.02

6.3.4 Procedure

The procedure was identical to that used in studies 1-3.

6.3.5 Analysis and results from Study 4

The results were analyzed for thirty 7-month-olds and thirty-three 11-month-olds from Urdu speaking homes. Each group included two subgroups of infants receiving opposite orders of presentation. An independent two-way ANOVA with age (2 levels: 7, 11 months) and order (2 levels: w-first, v-first) as the independent variables was run with discrimination values as the dependent variable. The main effect of age was significant (df = 1; F = 18.12; $p < 0.001$) which means that 7-month-olds showed higher discrimination value (M = 0.70; SD = 0.11) as compared to 11-month-olds (M = 0.56; 0.14). The main effect of order (df = 1; F = 6.29; $p < 0.05$) was also significant which means that the w-first order resulted in significantly higher discrimination values (M = 0.67; SD = 0.13) than the v-first one (M = 0.59; SD = 0.15). The interaction between age and order was not significant (df = 1; F = 1.85; ns). The discrimination values of both groups are presented in Figure 15.

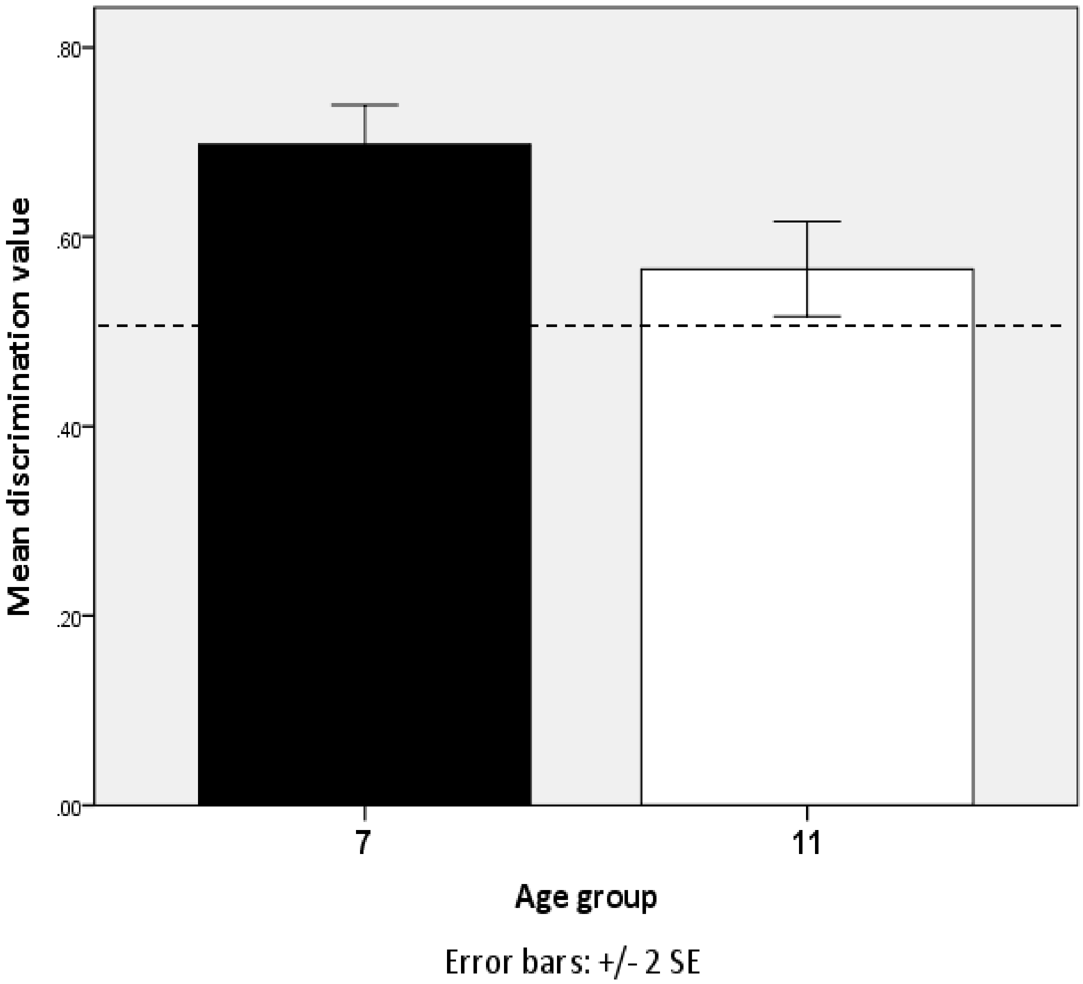

Figure 15 Discrimination values for 7- and 11- month olds in Study 4. The reference line shows the point of no discrimination, 0.5. Error bars: +/- 2 SE.

Note that the significance of the main effects of order and age meant that there was an order effect in the discrimination of non-native English stimuli for Urdu infants irrespective of age. In the older group, the mean discrimination value of the infants familiarized on the fricative /v/ and then tested on the approximant /w/ was 0.50 (SD = 0.14); the discrimination value for infants with the reverse order of presentation of stimuli was 0.62 (SD = 0.13). Among the 7-month-olds, the discrimination value of the infants familiarized on the fricative /v/ and tested on the approximant /w/ was 0.68 (SD = 0.11) and 0.712 (SD = 0.12) for the reverse order. Although no significant interaction was found between age and order, the order effects look more pronounced for the older group. The discrimination score of 11-month-olds with v-first order did not rise above the point of no discrimination, whereas the discrimination score of the infants with the reverse order was well above chance (see Figure 16).

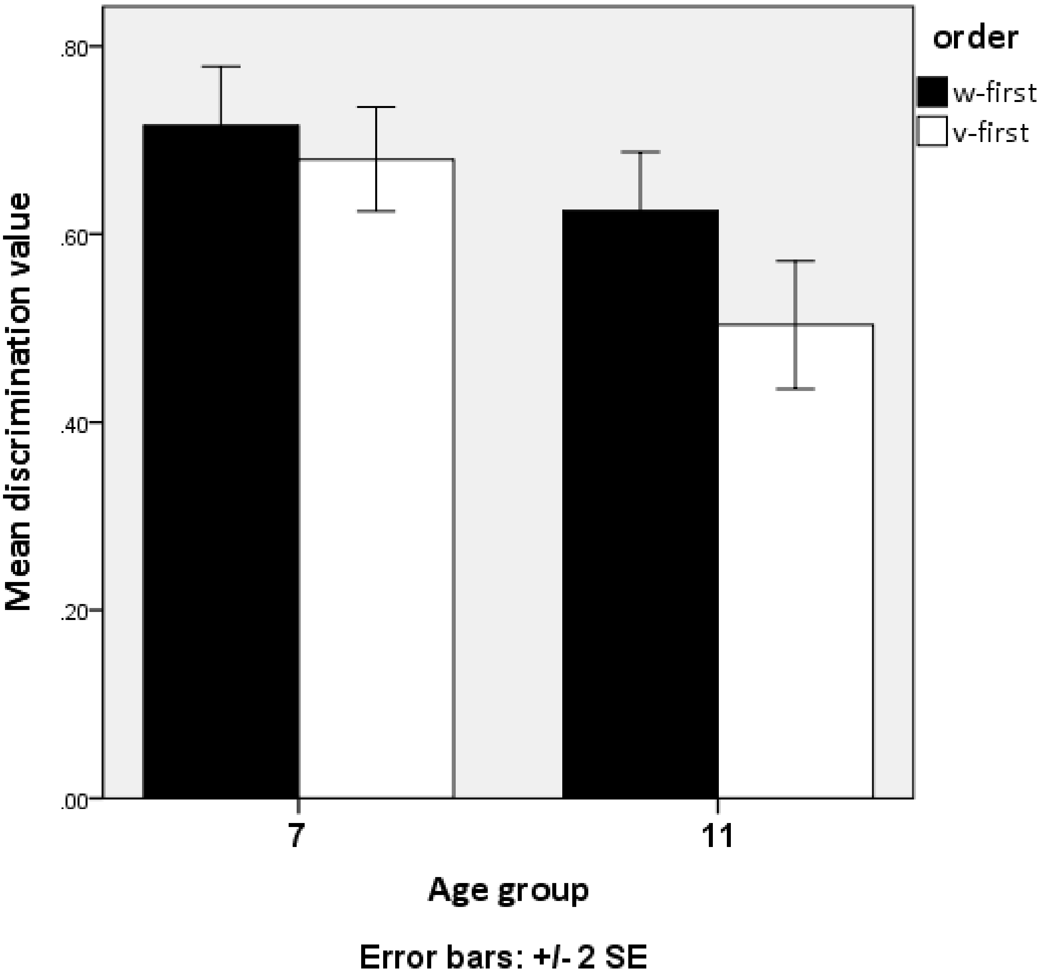

Figure 16 Discrimination values of 7- and 11-month olds by order of presentation of stimulus in Study 5. Error bars: +/- 2 SE.

An independent two-way ANOVA with age (2 levels: 7, 11 months) and order (2 levels: w-first, v-first) as the independent variables was run with habituation times as the dependent variable. The main effects of age and order were not significant (Age: df = 1; $F = 3.76$; ns; Order: df = 1; F = 0.54; ns). However, the interaction between age and order was significant (df = 1; *F* = 4.10; $p < 0.05$) with the two subgroups in 7-month-olds showing greater difference in the means (M = 74; SD = 45.72 for w-first; M = 104; SD = 53.60 for v-first) than the subgroups of 11-month-olds (M = 75; SD = 40.35 for w-first; M = 61; SD = 28.97 for v-first). A follow-up simple effects analysis showed significant effect in the habituation times of the two age groups for the v-first order (w-first: df = 1; *F* = 0.004; ns; v-first: df = 1; *F* = 7.748; $p < 0.01$). The interaction is plotted in the Figure 17.

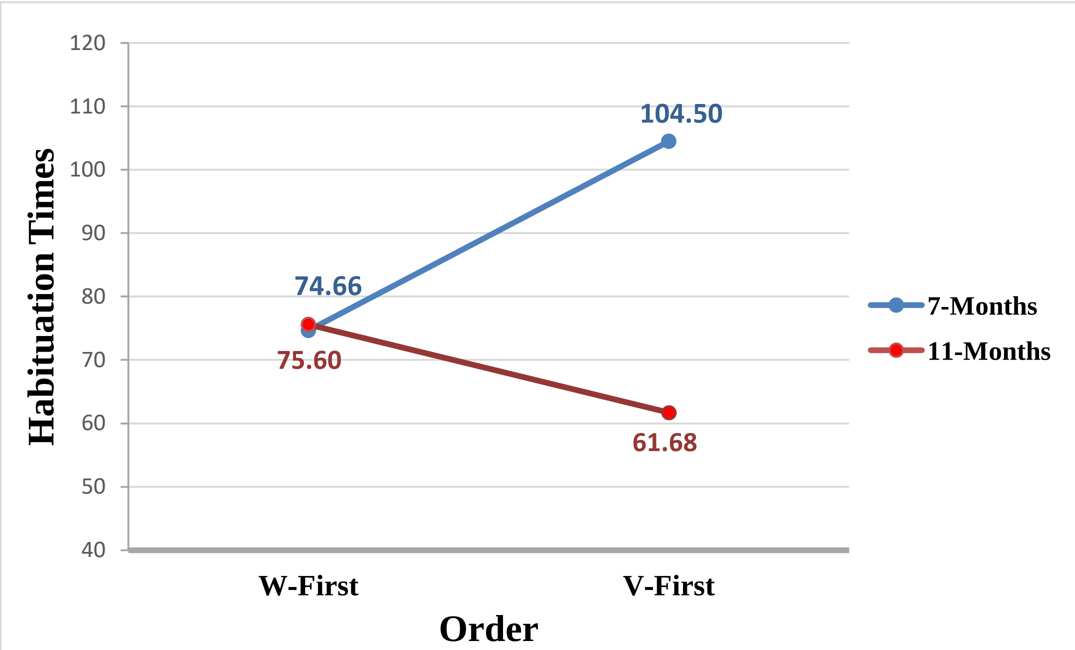

Figure 17 Interaction of the habituation time scores of both orders between the two age groups.

Another independent two-way ANOVA with age (2 levels: 7, 11 months) and order (2 levels: w-first, v-first) as the independent variables was run with habituation trials as the dependent variable. The main effect of order was not significant (df = 1; *F* = 1.38; ns). The main effect of age was significant (df = 1; *F* = 4.615; $p < 0.005$). The interaction between age and order was not significant (df = 1; *F* = 3.14; ns).

6.4 Summary

The results of Urdu infants in Study 4 gave interesting results. Unlike the previous studies, the order effect was found irrespective of age. In both age groups, the discrimination score was higher when the unfamiliar /w/ was presented first; however the discrimination value was significantly lower in the older group, which may indicate a decline in the ability to discriminate with age, but perhaps not yet a loss in this age group for this contrast. The habituation times and trials showed opposite results for both age groups; for 7-month-olds habituation was more rapid to the less familiar stimulus; for 11-month-olds habituation was more rapid to the familiar stimulus. The longer habituation time for v-first order by the 7-month-olds can be related to the nature of the fricative /v/ itself. There is ample evidence to suggest that fricatives are hard to discriminate in the early years, even when they play a functional role in the native language (Aslin & Pisoni, 1980; but see Tsao, Liu & Kuhl, 2006). This might explain the difference in the habituation times for v-first order between the younger and older group of infants.

Study 4 and all the previous studies showed order effects in infants from two language backgrounds on phonemic as well as allophonic contrast: Study 4 found order effects irrespective of age, whereas Studies 1-3 found order effects only in older infants. It is appropriate to ask when these asymmetries disappear. Study 3 found asymmetry in the perception of a non-native contrast even at 15 months of age? What about discrimination in later years? When do speakers of a given language stop discriminating between non-native speech contrasts? For study 5, adult native speakers of English and Urdu were tested on non-native contrast to find out if the asymmetries observed during infancy are maintained till adulthood. Both groups were also tested on a native contrast to compare their discrimination performance for two types of contrasts.

Chapter 7: Testing English and Urdu adults on native/non-native consonant contrasts

7.1 Order effects for consonants in adults:

Many studies have demonstrated order effects in adults for vowels (Repp, Healey & Crowder, 1979; Crowder, 1982; Cowan & Morse, 1986; Repp & Crowder, 1990; Shigeno, 1992) but the available data concerning the order effects in non-native consonants is very limited. Tsushima and his colleagues have conducted a series of studies examining the factors that may determine the direction and the magnitude of order effects, testing the English /b/-/v/ and /l/-/r/ contrast on adult Japanese speakers (Tsushima et al., 2001; Tsushima et al., 2003, 2005; Tsushima, 2007). Both /b/ and /v/ assimilate to Japanese /b/, although the English /v/ is phonetically (articulatorily and perceptually) more deviant for Japanese /b/. Also, the English /l/ is perceptually closer to the Japanese /r/, although both sounds of the American contrast /l/ and /r/ assimilate to Japanese /r/. The studies with /b/-/v/ contrast found that discrimination was lower when the first stimulus was more native-like: When the more native-like /b/ was presented first, the following /v/ got assimilated to it and no discrimination was observed (Tsushima et al., 2003, 2005). Similar results were obtained when adult speakers were tested with /l/-/r/ (Tsushima, 2007) and even when an unrelated vowel was inserted between the stimulus, both in an identification and AX discrimination task (Tsushima et al., 2005). The authors attributed the order effects to the perceptual magnet effect, stating that the direction of the order effects was most likely determined by the differential perceptual similarity of the stimuli to the native phonemic category to which they were perceptually assimilated. In their explanation they discussed an assimilation process where a sound phonetically close to a native phoneme (i.e., /b/) is perceived and stored in memory, which assimilates the following non-native sound (i.e., /v/) to the native-like /b/ category, making discrimination relatively difficult. Interestingly, in Werker et al. (1981, 1984) adults showed complete perceptual narrowing, failing to discriminate the non-native stimuli without specific training, whereas the experiments by Tsushima et al., (2001, 2003, 2005) and Tsushima (2007) showed order effects in adults' discrimination of two non-native contrasts. For study 5, adult native speakers of English and Urdu were tested on non-native consonant contrasts to see if the asymmetries, found in studies 1-4 in infants, could be observed in adults.

7.2 Study 5: Is the asymmetry for non-native consonants maintained through adulthood?

In the present study adults from English and Urdu speaking homes were tested on non-native Urdu and English stimuli to see if the order effects were maintained till adulthood. In order to find out the nature of asymmetries, adult participants were also tested on the native language[20]. The following research questions were addressed in Study 5;

1) Are the order effects observed in infants for non-native stimuli maintained till adulthood?

2) Do English and Urdu speakers show an order effect in the discrimination of non-native /tʃ/-/tʃʰ/ and /w/-/v/ respectively?

3) What about the native language? Is there an order effect in the discrimination of the native language contrast (/w/-/v/ for English speakers and /tʃ/-/tʃʰ/ for Urdu speakers)?

7.2.1 Subjects

[20] This was done in an attempt to find out if the asymmetries were language-specific (result of language experience) or language-general (universal). Universal bias can lead to asymmetries for both native and non-native contrasts.

a) ***English speakers:*** The adult English speakers (18 British, 2 Americans) were recruited through a) word of mouth, b) department of Language and Linguistic science at University of York and c) advertising on social media. A total number of 20 adults (12 females, 8 males) were recruited for the experiment. All adults were born and brought up in monolingual English speaking homes and were studying at the University of York at the time of the experiment (15 undergraduates, 3 Masters and 2 PhD students). The mean age was 26 (range 18 – 35 years).

b) ***Urdu speakers:*** Twenty adult Urdu speakers (11 male, 9 female) were recruited through a) word of mouth and b) friends and family. All adults were born and brought up in bilingual/multilingual homes in the capital city of Pakistan, Islamabad. None of the participants had ever lived in an English speaking country. All participants were University graduates (17 participants had a Masters degree, 2 had an undergraduate degree and 1 participant was currently pursuing PhD). The mean age was 30 (25-37 years).

7.2.2 Stimuli

a) ***Urdu stimuli:*** The stimuli consisted of 12[21] minimal pairs containing the Urdu affricate contrast /tʃ/ vs. /tʃʰ/ all word-initially. The stimuli were recorded by an adult female native Urdu speaker. Each of the consonant contrasts was recorded with a carrier sentence ‘can you say’ (**تم یہ بولو**). Each word was recorded three times, resulting in three different tokens of each word. We created 24 ‘different’ word pairs (minimal pairs) – 12 with the word containing the aspirated segment first and 12 with the word containing the unaspirated segment first. We also created 24 ‘same’ pairs, 12 with two different tokens of the same word, both including the unaspirated

[21] Three additional pairs were used in the test but were later taken out of the analyses, due to one member of the pair being a word and the other a non-word.

segment, and 12 with both tokens including the aspirated segment (see Appendix 2 for word list). No token was used more than once.

b) ***English stimuli:*** The stimuli consisted of 15[22] minimal pairs containing the English contrast /w/ vs. /v/ word initially. The stimuli were recorded by an adult female native English speaker. Each of the words was recorded with a carrier sentence 'can you say'. Each word was recorded three times, resulting in three different tokens of each word. We created 30 'different' word pairs (minimal pairs) – 15 with the word containing the w-first and 15 with the v-first words. We also created 30 'same' pairs, 15 with two different tokens of the same word, both including the w-first words, and 15 with both tokens including the v-first words (see Appendix 3 for word list). No token was used more than once.

7.2.3 Procedure

The adult participants were tested with an AX discrimination task using E-Prime. Each participant was auditorily presented with the minimal pairs over sound-cancelling Bose QC-15 headphones and asked to judge whether the word-initial consonants in the minimal pair were the same or different. Three practice trials were included at the start. Participants were asked to press a key ('s') if the two sounds in a pair seemed to be identical, and another key ('d') if the sounds were judged to be different. The intra-stimulus gap was 300 milliseconds and the order of stimuli was randomized. Each word pair was presented once in each of four combinations: AB (word A followed by word B), BA (word B followed by word A), AA (Word A repeated twice) and BB (Word B repeated twice), with no recorded token of any word being used more than once. In the practice trials, the participant was taken to the next pair only when the correct key had been pressed. The test trials then started

[22] The number of minimal pairs used for both English and Urdu participants was not consistent because of the reason stated in the previous footnote.

automatically. As soon as the participants pressed a response key, they were passed on to the next trial. There was no time limit for the response. Participants were tested individually in a quiet computer room.

7.2.4 Analysis

The results were analysed for twenty native English speakers and twenty native Urdu Speakers. All participants listened to the following four conditions: aspirated-first (different pair), unaspirated-first (different pair), aspirated-same and unaspirated-same (same pairs). A 2-tailed paired sample t-test was run to compare the ***'proportion of correct responses'*** and ***'average response time'*** in same and different trial types[23]. The 'proportion of correct responses' was computed for all participants by dividing the number of correct responses for all trial types by the total number of trials. For both 'proportion of correct responses' and 'average responses time', two paired t-tests were run, one between the different pairs (aspirated-first and unaspirated-first) and one between the same pairs (aspirated-same and unaspirated-same).

7.3 Results for Study 5

7.3.1 .Urdu affricate Contrast:

The response of one of the Urdu participants for the native Urdu affricate contrast was taken out of the analysis. The pattern of responses showed that the participant had not engaged with the task (responded *'same'* to 47 out of 48 trials). Since, that participant was a native Urdu speaker, it was extremely unlikely that the contrast

[23] 2-tailed paired t-tests were run within different and same trial types to compare the performance of participants within each trial type as the two trial types are not comparable to each other. The responses that participants chose for each trial type conveyed two different meanings. Responses in the *'different'* trials showed the participants' ability to perceive the **difference** between the two sounds. It also indicated the possibility of an **order effect** i.e. if discriminability for w-v pair was higher as compared to v-w and vice versa. Responses in the *'same'* trials indicated participants' ability to perceive **sameness**; order effect became irrelevant here as the two sounds in a pair were the same.

would have been difficult for that native Urdu participant. The results were analysed for nineteen native Urdu speakers and twenty English speakers.

For the Urdu affricate contrasts a 2-tailed paired-samples run on English participants indicated no significant difference in the ***'proportion of correct responses'*** in the *'different'* conditions; aspirated-first (M = 0.71, SD = 0.15) and unaspirated-first (M = 0.72, SD = 0.150, t = -0.41, df = 19; p = ns) [24]. For Urdu participants the mean scores were also not significantly different within the *'different'* trial types (aspirated-first: M = 0.95, SD = 0.24; unaspirated-first: 0.83, SD = 0.25, t = -1.22, df = 19, p = ns). For the *'same'* trials no significant differences were found for both English (aspirated-same; M = 0.68, SD = 0.16; unaspirated-same: M = 0.66, SD = 0.14, t = 0.38, df = 19, p = ns) and Urdu adults (aspirated-same: M = 0.90, SD = 0.15; unaspirated-same: M = 0.86, SD = 0.11, t = -0.95, df = 19, p = ns). The results indicate that no order effects were found in the discrimination of non-native Urdu stimuli for English and Urdu adults.

Next 2-tailed paired sample t-tests were run on the ***'average reaction times'*** on same and different trial types for both English and Urdu adults. The average responses times were not significantly different within the *'different'* condition for English adults (aspirated-first: M = 1519, SD = 543; unaspirated-first: M = 1490, SD = 421, t = 0.43, df = 19; p = ns). Similar non-significant differences were found for Urdu adults (aspirated-first: M = 1167, SD = 301; unaspirated-first: M = 1089, SD = 262, t = 1.42, df = 19; p = ns). For the *'same'* conditions, the mean reaction times were also not significantly different in either English (aspirated-same: M = 1613, SD = 480; unaspirated-same: M = 1614, SD = 585, t = -0.01, df = 19, p = ns) or Urdu adults

[24] The results here are very different from English adults in the pilot study. Adults in the pilot study had an error rate of 75%, whereas English adults here in Study 5 performed above chance. The possible reason for the discrepancy is discussed in the next chapter.

(aspirated-same: M = 1225, SD = 387; unaspirated-same: M = 1235, SD = 537, t = -0.089, df = 19, p = ns). Thus, no order effects were found for average reaction times in both English and Urdu adults for Urdu affricate contrast.

7.3.2: English /w-v/ contrast:

For the English contrast no significant differences were found in the ***'proportion of correct responses'*** within the *'different'* conditions for English adults (w-first: M = 0.98, SD = 0.04; v-first: 0.967, SD = 0.05, t = 0.44, df = 19, p = ns). However, for Urdu participants the mean scores were significantly different within the two *'different'* conditions (w-first: M = 0.59, SD = 0.25; v-first: 0.44, SD = 0.25, t = 3.47, df = 19, $p < 0.005$). The analysis of the *'proportion of correct responses'* for the *'same'* conditions yielded non-significant differences within the two conditions for English adults (w-same: M = 0.99, SD = 0.02; v-same: M = 0.97, SD = 0.056, t = 1.90, df = 19, p = ns), whereas significant differences were found for Urdu adults (w-same: M = 0.83, SD = 0.16; v-same: M = 0.76, SD = 0.20, t = 2.21, df = 19, $p < 0.05$). The results show order effect in Urdu adults in the discrimination for non-native English contrast, no order effects were seen for English adults. Note that English speakers performed above chance on all trial types on the native English stimuli. Urdu speakers performed above chance on all but the v-first different trial. The proportion of correct responses was much higher for the 'same' as compared to the 'different' conditions; thus *'same'* response was selected more often than 'different'. Figure 18 below summarizes the results for Urdu adults;

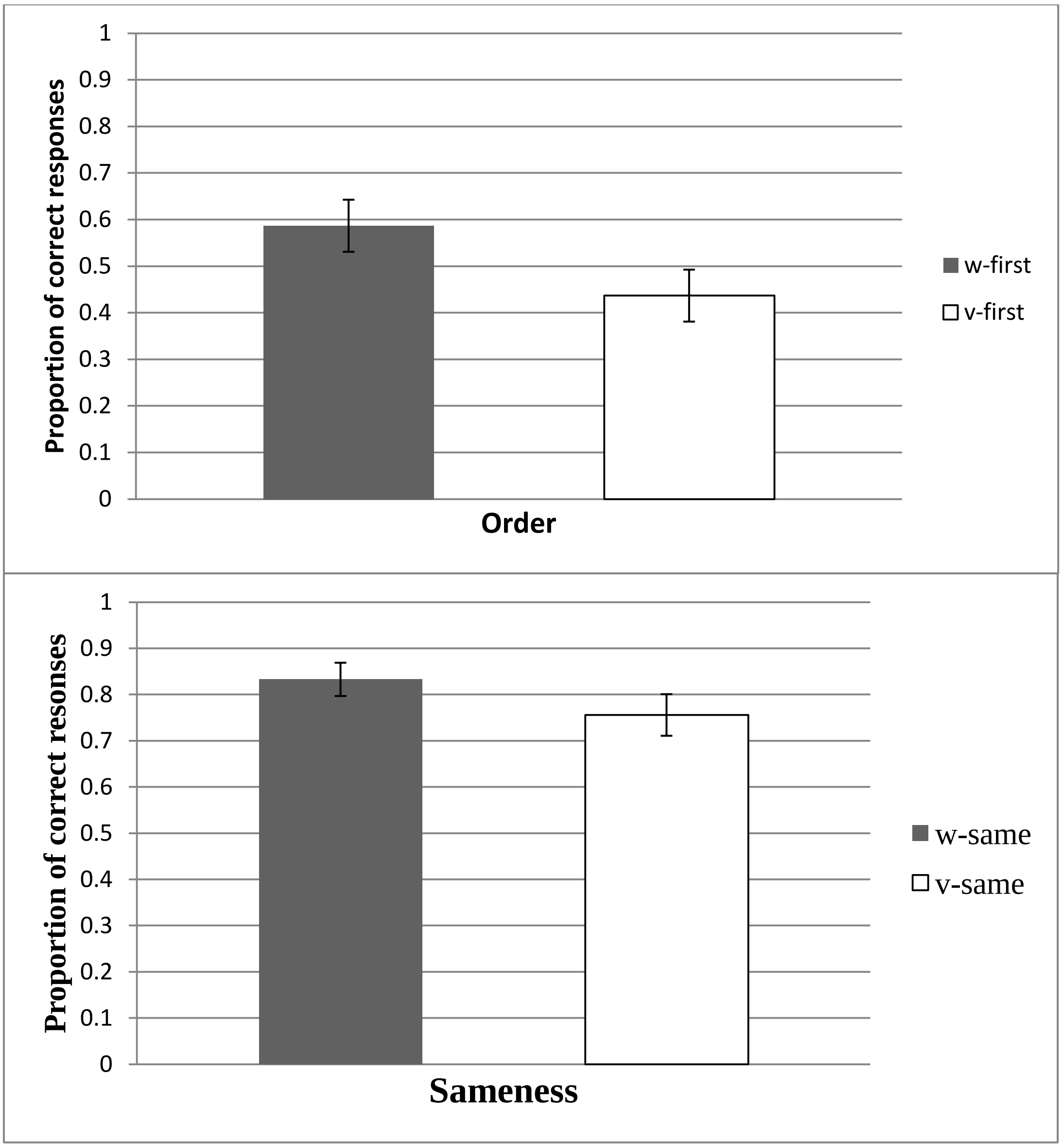

Figure 18 Proportion of correct responses of native Urdu speakers for the fifteen non-native English pairs. The top part represents the order in which the consonants were presented within two different pairs (w-first and v-first). The bottom presents the proportion of correct responses within the two same pairs. Errors bars show the standard error which was calculated by squaring the standard deviation of the mean scores.

Next 2-tailed paired sample t-tests were run on the ***'average reaction times'*** on same and different trial types for both English and Urdu adults. For the English adults, no significant differences were found within the *'different'* conditions (w-first: M = 1317, SD = 199; v-first: M = 1337, SD = 194, t = -0.43, df = 19; p = ns). Similar results were observed for Urdu adults (w-first: M = 1413, SD = 227; v-first:

M = 1552, SD = 400, *t* = -1.75, df = 19; *p* = ns). Within the *'same'* conditions, the mean scores were not significantly different in both English and Urdu adults (*English adults*: w-same: M = 1303, SD = 210; v-same: M = 1357, SD = 266, *t* = -1.20, df = 19, *p* = ns; *Urdu adults*: w-same: M = 1340, SD = 309; v-same: M = 1465, SD = 418, *t* = -1.86, df = 19, *p* = ns). Hence no order effects were found in both English and Urdu adults in the average reaction time for Urdu affricate contrast.

7.4 Summary

Study 5 was conducted to find out if English and Urdu speaking adults would show order effects in their discrimination of either native or non-native consonant contrasts. Adult groups were tested on the consonants similar to the infant groups in studies 1-4. Although English adults did not show order effects for non-native Urdu contrast, their performance was above chance. For the English /w-v/ contrast, English adults performed significantly above chance on all trial types, whereas Urdu speakers performed above chance on all but the v-first condition. The mean scores were much higher for the 'same' trial types in Urdu respondents; 'same' response was selected more often than 'different'. These results indicate that order effects were maintained only for Urdu participants into adulthood for the non-native English contrast: The asymmetry found in English infants for non-native Urdu consonant disappeared between 15 months to adulthood. The results from Study 5 and all previous studies 1-4 are discussed in detail in the next chapter.

Chapter 8: Discussion

8.1 General Discussion

This study investigated order effects in infants and adults from English-and Urdu speaking homes on English approximant-fricative /w-v/ contrast and Urdu aspirated-unaspirated affricate contrast /tʃ/ - /tʃʰ/. In Study 1, English infants from two age groups, 7-and 11-months, were tested on a non-native Urdu contrast. The 7-month-olds were successful in discriminating the affricate pair, whereas a decline in perception for the non-native contrast was found in 11-month-olds, in line with previous studies. Study 1 also found that in 11-month-olds discrimination was better when the infants were familiarized with the aspirated affricate before being tested with the contrasting stimulus, but the sample was too small to allow clear conclusions to be drawn. Study 2 was specifically designed to further investigate this issue by recruiting a larger sample; the results from this study confirmed the asymmetry in the English infants at the end of the first year for the non-native Urdu affricate contrast. In study 3, the older infants from Study 2 were tested again at 15 months of age and a similar asymmetry was found; the older group of infants when listened to aspirated-first /tʃʰ/ first showed discrimination but the infants who listened to unaspirated-first /tʃ/ did not. In an attempt to find the evidence for asymmetries in a different language group, Study 4 tested 7- and 11-month-olds from Urdu speaking homes on a non-native English contrast /w-v/ and found asymmetries irrespective of age. Infants from both age groups discriminated better when /w/ was presented first. Note that the asymmetries observed in infants from two different language backgrounds cannot be taken as evidence against perceptual narrowing: the presence of order effects in English 11-and 15-month-olds but not in 7-month-olds suggest that there was a decline in perception at the end of first year.

As discussed previously, infants' early experience with language input plays a vital role in shaping their perceptual development. If two sounds do not contrast in the infants' language environment, the lack of perceptual experience with the contrast attenuates infants' ability to recognize it (Maye, Werker & Gerken, 2002). This attenuation makes the perception of stimuli in the region of that particular perceptual boundary less noticeable by forming single broad category for that given sound contrast. In Study 1, 7-month-olds, prior to the time when infants' perceptual development becomes attuned to the phonological categories of the ambient language, the infants in this study were able to discriminate the contrast. As the aspirated-unaspirated affricate contrast does not occur in English and infants are exposed only to unaspirated consonants, the input to English-learning infants likely has a unimodal distribution, which leads to the formation, towards the end of the first year, of a broad single category for voiceless affricates rather than of two separate categories. This native category learning can make the discrimination of the non-native aspirated-unaspirated affricate contrast more difficult to discriminate: The two phones fall within a single category for English (voiceless alveolar affricate), and differ in category goodness. Study 1 indeed showed the decline in discrimination of the contrast in 11-month-olds as a group.

Seen from an exemplar theory point of view, the native language category that results from this early language experience most likely consists of a cloud of exemplars; the more prototypical tokens (with strong category membership) occupy the central position and the less prototypical ones (less strong category membership) are closer to the category boundary (see Grieser & Kuhl (1989) for a detailed discussion of how infants organize speech categories around prototypes). As suggested by Kuhl (2004), the central exemplar (or prototype) functions as a perceptual magnet, in that the activation of the prototype of a given category reduces the ability to discriminate a following variant of the same category by shrinking the perceptual space around it (in other words, the prototype acts as a magnet). This effectively shortens the distance between the prototype and the not-so-prototypical tokens within the same category (Kuhl et al., 1992); a non-prototypical consonant does not have this effect. This leads to order effects in the discrimination of a non-native contrast when the direction of presentation of the stimuli is counterbalanced in a given task, as demonstrated in studies 1-4. The Urdu contrast /tʃ/ - /tʃʰ/ assimilates to a single broad category for infants from English-speaking homes. Even though the Urdu affricates assimilate to a single native category /tʃ/ in English infants, the two non-native consonants differ in category goodness, one being a good exemplar and the other a deviant one (based on Best's 1993 taxonomy; see Werker et al., 1981, 1983, 1984; Kuhl, 2004; Kuhl et al., 2008). For the Urdu affricate contrast, the /tʃ/ (VOT +80 ms) is very close the English unaspirated affricate (+83 ms) and is likely perceived as *prototypical*. The Urdu voiceless aspirated affricate /tʃʰ/ (+140 ms) does not exist in English and is likely perceived by infants learning English as *a non-prototypical* variant of the /tʃ/ category. In the case of non-native English stimuli /w-v/ for Urdu infants, there seems to be no allophonic variation, as suggested previously. The acoustic analysis of Urdu /w-v/ suggested that the labio-dental approximant [ʋ] has replaced [w] (it can be termed *non-prototypical*) and is likely realised either as a mixed articulation [ʊ͡v] or [ʋ]. In studies 2-4, when the 11-month-olds heard the familiar or prototypical sound in the familiarization phase (/tʃ/ for English infants and /v/ for Urdu infants), this may have activated various familiar exemplars, resulting in strong activation of that phonetic category. Arguably, this would have led to assimilation of the non-prototypical sound presented subsequently, blocking discrimination. On the other hand, when the unfamiliar or non-prototypical sound was played first (/tʃʰ/ for English infants and /w/ for Urdu infants), it can be taken to have failed to activate familiar exemplars or it may have activated exemplars of different kinds, belonging to no one category. The infants would have been unable to relate it straightforwardly to anything they had heard before. Thus it would have presented a sharp contrast to the native-like sound that followed (which would have resulted in activating a phonetic category), facilitating discrimination of the test stimuli. This may have led to asymmetries observed in infants from English and Urdu speaking homes in studies 1-4.

After observing asymmetries in infants from 11-15 months of age, adult participants were tested on native as well non-native consonants to find out if the order effects are maintained till adulthood. In Urdu adults, significant order effects were observed in the discrimination of non-native /w/-v/ contrast. The discrimination was better when the adult participants heard the /w/ first (the sound that does not exist in Urdu): The Urdu adults showed an asymmetry similar to what was shown by the older Urdu infants. English adults showed no asymmetry for the non-native Urdu consonant contrast, although the discrimination was above-chance. The PAM model (Best, 1993) suggests that when mature listeners hear non-native phones, they evaluate them on the basis of their gestural similarities to the native sounds. A listener will not be able to detect discrepancies if the articulatory-gestural properties of the non-native sound are similar to the native sound: It will be assimilated to the native category that is perceived to be most similar to the non-native sound. Note that although the Urdu contrast was assimilated to the native category /tʃ/, one of the consonants in the Urdu contrast /tʃ/-/tʃʰ/ was more native-like than the other. Liberman, Cooper, Shankweiler and Studdert-Kennedy (1967) pointed out that assimilation is not all or none and there is some above-chance within-category discrimination and sensitivity to gestural variations (Pisoni and Lazarus, 1974; Carney, Widin, and Viemeister 1977; Best, Morrongiello, and Robson, 1981; Werker and Logan, 1985). In a non-native contrast, the discrepancies between the two sounds are often recognized. This might result in discrimination even though the two sounds assimilate to a single phonetic category in the native language (Best, 1993). It is thus possible that the voiceless affricate was perceived as a better exemplar of English /tʃ/ category than /tʃʰ/, as adult listeners can differentiate between good and less-good exemplars which may lead to discrimination (based on Best's 1993 taxonomy; see Werker et al., 1981, Werker & Tees, 1983, 1984; Best, McRoberts, & Goodell, 2001; Kuhl , 2004; Kuhl et al., 2008). That can explain the above-chance results achieved for English listeners for non-native /tʃ/-/tʃʰ/ in the AX discrimination task, which is comparable to other adult perception studies in literature non-native contrasts. Hattori and Iverson (2009) tested Japanese adults on English /la/-/ra/ found that the subjects identified the correct phoneme around 70% of the time (71% correct identification for /r/ and 67% correct identification for /l/). Similar results were obtained with native speakers of Saudi Arabic who identified non-native English contrast /p/-/b/ at above-chance level: Correct identification rates for /p/ and /b/ were 74% and 68% respectively (Alshangiti, 2015).

Note that considerable difference was found in the discrimination performance of English adults for non-native Urdu consonants between the pilot study and Study 5. This difference can be interpreted in the light of other adult discrimination studies showing the effects of task familiarity on discrimination (Tsushima et al., 2003, 2005; Tsushima 2007, 2011). In Tsushima et al. (2003), order effects in the expected direction were systematically observed only in the pretest, comparable to our study, but not after repeated training with the same stimuli over several days. The authors attributed the disappearance of the order effects after the pretest to participants' increased proficiency at discriminating the contrast. In Tsushima (2011) Japanese adults were again tested on the /b/-/v/ stimuli, using a fixed category procedure (for half of the listeners /b/ always occurred first and vice versa). It was found that the participants in the /b/-first group were able to take advantage of the frequent presentation of /b/ as the first stimulus by picking up critical acoustic cues that helped in discrimination - and that are also used in the native language. Due to their unfamiliarity with the acoustic properties of /v/ the adults in the /v/-first group could not similarly gain from the repeated presentations. In the /b/-first, with increased familiarity, this order effect not only disappeared, but was reversed (see Tsushima, 2007, for similar results for /l-/r/). The English adults in Study 5 listened to 48 pairs of minimal pairs featuring /tʃ/-/tʃʰ/, those in the pilot to only 2 pairs. It is possible that in Study 5 the discrimination of English-speaking adults improved as their increased familiarity with the stimuli increased, leading to relatively high performance and a loss of the order effect.

Since the asymmetries observed with respect to magnet effect are due to native language category learning and not due to inherent acoustic properties, these effects are not expected in the early years of life when infants have not yet formed robust representations or memory of native language sounds. This is what we found in the present study; the 7-month-olds did not show an order effect for the non-native affricate contrast, only English 11- and 15-month-olds did. For Urdu infants, although order effect was found regardless of age, difference in mean discrimination score between the two orders was more pronounced in the older group. Also, no difference was found in the habituation time or number of trials to habituation between infants exposed to the two different orders in either age groups. This suggests that nothing inherent in either member of the affricates or fricative-approximant contrast makes them easy or difficult for infants to habituate to. Also note that in Study 5 with adults, no order effects were observed for either English or Urdu adults for native language stimuli; this suggests that the asymmetries might not have resulted from the stimuli being inherently, or acoustically, more salient. Order effect is not an artefact of universal bias but rather is linked with a learnt perceptual behaviour. In studies 1-5, the native language categories appear to have affected the ability to discriminate a non-native contrast and the order of presentation effects demonstrated by infants and adults were a consequence of their linguistic processing of speech stimuli which resulted in discrimination in one order but not the other.

8.2 Summary & Conclusion

The present study has shown that ambient language experience leads to the formation of phonetic categories which reshape the perceptual space underlying speech. The phonetic prototype (central token) from any given category perceptually attracts surrounding stimuli, affecting the discrimination of native as well as foreign language contrasts. Thus, the phonetic categories of one's own language form a 'sieve' through which the phonetic units of the foreign language must pass (Trubetzkoy, 1939). The nearer a foreign sound is to a magnet, the more it will be assimilated to the native language category, making it distinguishable from the native-language sound (Best, 1993). Note that categorical representations and their internal structure are not restricted to sounds; studies have shown that infants have the ability to abstract a central category representation across various domains from a very young age (Kuhl & Iverson, 1995). Newborns react to composites of individual faces within 1 minute of exposure to the individual faces (Walton & Bower, 1993), which shows that composites are attractive to infants and readily formed in a very short time. This suggests that category representations (and the internal distribution) formed early in life across various sensory domains reflect infants’ disposition to structure by similarity (See also Handel & Garner, 1966; Garner, 1974; Rosch, 1975; Bornstein, Kessen & Weiskopf, 1976; Quinn, Eimas & Rosenkrantz, 1993 for detailed discussion on categorical representations in domains such as geometric forms, female faces, line drawings of animals, colours and oblique lines and prototypical structure of these categories).

An important question to ask here is what role do these speech representations/categories play in language learning in general? Studies suggest that speech representations that are being formed as a result of experience are not just auditory in nature. Infants have the capacity to imitate speech vocally very early in life; as early as 12 weeks of age they move their own articulators to replicate certain features of the sounds that they hear (Kuhl 1994; Meltzoff & Kuhl, 1994). The speech representations are initially auditory, but they extend to other sensory domains (or are polymodal); as infants acquire more exposure they relate auditory information to not only the visual information of a given sound but the movements required by their own articulators to produce it (Kuhl & Iverson, 1995). Thus, well before infants utter or understand their first words, they demonstrate an ability to learn simply by listening to the ambient language. This forms a linguistic representational system that alters both the perception of speech and its production. The perceptual magnet effect thus illustrates how exposure to language alters perception and may generally reflect a mechanism by which experience can alter the mind of an individual.

8.3 Suggestions for future research

The findings of order-effects in non-native consonant discrimination opens up a new line of research, which may shed new light on adult as well as infant processing of consonants. A number of interesting questions that were not within the scope of the research remain unanswered.

a) In Study 2 the presentation of /tʃ^{h}/ in the first phase aided the English-learning infants' discrimination, but can similar results be obtained with infants from Urdu-speaking homes? What about English infants if tested on /w/-/v/? It is speculated in this study that the order effects were language-related. That implies that these kinds of order effects can only be observed when the stimuli consist of a contrast in which non-native consonants differ in category goodness, one being a good exemplar and the other a deviant one. It remains for future studies to test Urdu-learning infants on the native affricate contrast /tʃ/ - /tʃ^{h}/ and English infants on native /w-v/ contrast to confirm that the order effects observed in studies 2-4 were language- related and not due to a universal bias.

b) The effect of age is yet another issue: Are the asymmetries maintained at later stages for the contrasts that do not become functional in the native language? Study 3 showed that English infants showed order effects by 15 months of age but those order effects disappeared by adulthood. There is no study to show when the order effects go away resulting in complete assimilation of the non-native sound contrast into a single category. Further studies in this field can attempt to unfold this by testing infants at different ages.

APPENDICES

APPENDIX I: ACCOMPANYING ETHICS DOCUMENTATION

I.A Information sheet for English infants (Study 1 & 2)

THE UNIVERSITY *of York*

DEPARTMENT OF
LANGUAGE AND
LINGUISTIC SCIENCE
Heslington, York, YO10 5DD, UK
Phone number 07466834124
Email mariam.dar@york.ac.uk

INFORMATION SHEET

PLEASE KEEP THIS INFORMATION SHEET AND A SIGNED COPY OF THE CONSENT FORM FOR YOUR RECORDS

You are invited to take part in a research study. Before you decide whether to participate it is important for you to understand why the research is being done and what it will involve. Please take the time to read the following information carefully. If there is anything you do not understand, or if you want more information, please ask the researcher.

Title of study:
Order effects in English and Urdu speaking infants' and adults' discrimination of non-native consonants: Urdu Affricate /tʃ/-/tʃʰ/ and English approximant-fricative /w/-/v/ contrasts

Researcher: Mariam Dar

What is the research about?

This is a study related to my PhD dissertation. I am investigating how English-speaking infants and adults distinguish speech sounds. I started out by determining which Urdu speech contrasts are difficult for English-speaking adults to differentiate. The Urdu speech contrasts which were found to be most difficult for the adults to distinguish will now be used to test infants belonging to English speaking communities. Infants will be tested at 7 and 11 months of age to see at which point in time the infants' ability to distinguish non-native speech contrasts starts diminishing. Adult responses will also be compared to infants' responses.

Why is the research being carried out?

The research is being carried out to see if there is a difference between the way adults and infants distinguish non-native speech sounds. We also aim to find out if the order of presentation of speech sounds affects the way they are perceived by both infants and adults.

1

Who is carrying out the research?

The research is being carried out by Mariam Dar, under the supervision of Professor Marilyn Vihman and Dr. Tamar Keren-portnoy of the Department of Language and Linguistic Science at the University of York.

Who can participate?
There are some restrictions as to who can participate in this study.
Your infant can participate if:
(i) He/she is 7 or 11 months of age.
(ii) His/her parents are a native speaker of British English
(iii) He/she is brought up in a household where only British English is spoken

What does the study involve?

The data will be collected from 7- and 11-month old infants from the English speaking community. The infants will listen to Urdu/Hindi speech sounds and their discriminatory abilities will be assessed through habituation-dishabituation looking procedure. The infants will be identified from the city of York and parents will be requested to bring the infants to the university. The procedure will be carried out in the Infant and Toddler lab in Department of Linguistics. You will be with your child throughout the session. The procedure will take around 10-20 minutes per infant. You will be paid £10 for your time.

During the procedure your child will be sitting on your lap, facing a checkerboard display. You child will be played different sounds through loudspeakers, and the length of time that they attend to the sounds will be measured. I will ask you to wear headphones playing speech sounds that make it difficult or impossible for you to hear the speech that your child is hearing. This ensures that your response will not influence your child's response in any way.

Do I have to take part?

You do not have to take part in the study. If you do decide to take part you will be given this information sheet to keep and will be asked to sign two copies of the consent form (one copy is for you to keep). If you decide to take part you will still be free to withdraw at any time without giving a reason. If you withdraw from the study, we will destroy your data in all forms and will not use it in any way.

What are the possible risks of taking part?

The study poses no foreseeable risk to you or your children. If at any stage your child becomes distressed, I will end the session.

Are there any benefits to participating?

You will be participating in an exciting new piece of linguistic research that may help linguists better understand the differences in speech perception between adults and infants.

There are no direct benefits to you.

What kind of information do I have to give?

The Infant and Toddler lab team already have your contact details. I will not ask for any additional details from you. You will be asked for an email address so that I can send you the forms as well as a summary of the results. Your identity and your child's will be kept confidential and will not be revealed in any publication or presentation.

What will happen to the data I provide?

The data you provide will be kept safely on university computers and will be backed up. It will be analysed to find out what is easy/difficult for English speakers to hear. The results will be reported in presentations and one or more academic papers. The data may also be kept after the duration of the current project, to be used in future research on language.

What about confidentiality?

Your identity and your child's will be kept strictly confidential. No real names will be used in any presentations or publications. Your data will be stored securely in the University of York, Department of Language and Linguistic Science.

Will I know the results?

I will not be able to give you feedback on your child's individual results. However, after the study has been completed, I will email the summary of the results if you will provide your email address.

*This study has been reviewed and approved by the Departmental Ethics Committee of the Department of Language and Linguistic Science at the University of York. If you have any questions regarding this, you can contact the head of the Ethics Committee, Tamar Keren-Portnoy (**email:** tamar.keren-portnoy@york.ac.uk; **Tel:** (01904) 323614).*

If you have further questions regarding this study, please feel free to contact:
Researcher name: Mariam Dar
Email address: md738@york.ac.uk
Department of Language and Linguistic Science
University of York, Heslington, York, YO10 5DD
tel: 07466834124
email: md738@york.ac.uk

Supervisors' details
Marilyn Vihman & Tamar Keren-Portnoy
Contact addresses: Marilyn.vihman@york.ac.uk, tamar.keren-portnoy@york.ac.uk

I.B Information Sheet for English infants in Study 3 (15-month-olds)

THE UNIVERSITY *of York*

DEPARTMENT OF
LANGUAGE AND
LINGUISTIC SCIENCE
Heslington, York, YO10 5DD, UK
Phone number 07466834124
Email mariam.dar@york.ac.uk

INFORMATION SHEET

PLEASE KEEP THIS INFORMATION SHEET AND A SIGNED COPY OF THE CONSENT FORM FOR YOUR RECORDS

You are invited to take part in a research study. Before you decide whether to participate it is important for you to understand why the research is being done and what it will involve. Please take the time to read the following information carefully. If there is anything you do not understand, or if you want more information, please ask the researcher.

Title of study:
Order effects in English and Urdu speaking infants' and adults' discrimination of non-native consonants: Urdu Affricate /tʃ/-/tʃʰ/ and English approximant-fricative /w/-/v/ contrasts

Researcher: Mariam Dar

What is the research about?

This is a study related to my PhD dissertation. I am investigating how English-speaking infants and adults distinguish speech sounds. I started out by determining which Urdu speech contrasts are difficult for English-speaking adults to differentiate. The Urdu speech contrasts which were found to be most difficult for the adults to distinguish will be used to test infants belonging to English speaking communities. In the present study infants who were tested at 11 months in the previous study will be tested again at 15 months of age to see at which point in time the infants' ability to distinguish non-native speech contrasts starts diminishing. Adult responses will also be compared to infants' responses.

Why is the research being carried out?

The research is being carried out to see if there is a difference between the way adults and infants distinguish non-native speech sounds. We also aim to find out if the order of presentation of speech sounds affects the way they are perceived by both infants and adults.

Who is carrying out the research?

The research is being carried out by Mariam Dar, under the supervision of Professor Marilyn Vihman and Dr. Tamar Keren-portnoy of the Department of Language and Linguistic Science at the University of York.

Who can participate?
There are some restrictions as to who can participate in this study.
Your infant can participate if:
(i) He/she is 15 months of age.
(ii) His/her parents are a native speaker of British English
(iii) He/she is brought up in a household where only British English is spoken

What does the study involve?

The data will be collected from 7- and 11-month old infants from the English speaking community. The infants will listen to Urdu/Hindi speech sounds and their discriminatory abilities will be assessed through habituation-dishabituation looking procedure. The infants will be identified from the city of York and parents will be requested to bring the infants to the university. The procedure will be carried out in the Infant and Toddler lab in Department of Linguistics. You will be with your child throughout the session. The procedure will take around 10-20 minutes per infant. You will be paid £10 for your time.

During the procedure your child will be sitting on your lap, facing a checkerboard display. You child will be played different sounds through loudspeakers, and the length of time that they attend to the sounds will be measured. I will ask you to wear headphones playing speech sounds that make it difficult or impossible for you to hear the speech that your child is hearing. This ensures that your response will not influence your child's response in any way.

Do I have to take part?

You do not have to take part in the study. If you do decide to take part you will be given this information sheet to keep and will be asked to sign two copies of the consent form (one copy is for you to keep). If you decide to take part you will still be free to withdraw at any time without giving a reason. If you withdraw from the study, we will destroy your data in all forms and will not use it in any way.

What are the possible risks of taking part?

The study poses no foreseeable risk to you or your children. If at any stage your child becomes distressed, I will end the session.

Are there any benefits to participating?

You will be participating in an exciting new piece of linguistic research that may help linguists better understand the differences in speech perception between adults and infants. There are no direct benefits to you.

What kind of information do I have to give?

The Infant and Toddler lab team already have your contact details. I will not ask for any additional details from you. You will be asked for an email address so that I can send you the forms as well as a summary of the results. Your identity and your child's will be kept confidential and will not be revealed in any publication or presentation.

What will happen to the data I provide?

The data you provide will be kept safely on university computers and will be backed up. It will be analysed to find out what is easy/difficult for English speakers to hear. The results will be reported in presentations and one or more academic papers. The data may also be kept after the duration of the current project, to be used in future research on language.

What about confidentiality?

Your identity and your child's will be kept strictly confidential. No real names will be used in any presentations or publications. Your data will be stored securely in the University of York, Department of Language and Linguistic Science.

Will I know the results?

I will not be able to give you feedback on your child's individual results. However, after the study has been completed, I will email the summary of the results if you will provide your email address.

*This study has been reviewed and approved by the Departmental Ethics Committee of the Department of Language and Linguistic Science at the University of York. If you have any questions regarding this, you can contact the head of the Ethics Committee, Tamar Keren-Portnoy (**email:** tamar.keren-portnoy@york.ac.uk; **Tel:** (01904) 323614).*

If you have further questions regarding this study, please feel free to contact:
Researcher name: Mariam Dar
Email address: md738@york.ac.uk
Department of Language and Linguistic Science
University of York, Heslington, York, YO10 5DD
tel: 07466834124
email: md738@york.ac.uk

Supervisors' details
Marilyn Vihman & Tamar Keren-Portnoy
Contact addresses: Marilyn.vihman@york.ac.uk, tamar.keren-portnoy@york.ac.uk

I.C Consent Form for English infants in Study 1, 2 & 3

Title of project: Order effects in English and Urdu speaking infants' and adults' discrimination of non-native consonants: Urdu Affricate /tʃ/-/tʃʰ/ and English approximant-fricative /w/-/v/ contrasts

Lead researcher: Mariam Dar

Consent form

This form is for you to state whether or not you agree to take part in the study on the behalf of your child. Please read and answer every question. If there is anything you do not understand, or if you want more information, please ask the researcher.

Have you read and understood the information leaflet about the study?	Yes ☐ No ☐
Have you had an opportunity to ask questions about the study and have these been answered satisfactorily?	Yes ☐ No ☐
Do you understands that the information provided will be held in confidence by the research team, and your child's name or identifying information about your child will not be mentioned in any publication?	Yes ☐ No ☐
Do you understand that you may withdraw your agreement to your child's taking part in the study at any time before the actual test session without giving any reason, and that in such a case all your child's data will be destroyed?	Yes ☐ No ☐
Do you understand that the information your child provide may be kept after the duration of the current project, to be used in future research on language?	Yes ☐ No ☐
Do you agree to take part in the study?	Yes ☐ No ☐
Do you understand that there will a video recording of your child's responses in the study?	Yes ☐ No ☐
Do you agree to the researcher's keeping your contact details after the end of the current project, in order that s/he may contact you in the future about possible participation of your child in other studies? *(You may take part in the study without agreeing to this).*	Yes ☐ No ☐

Your name (in BLOCK letters):

____

Email address: (Please write your email address if you want the summary of results)

____

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Your signature:
____

Researcher's name:
____

Date: ____

I.D Information sheet for Urdu infants in Study 4

THE UNIVERSITY *of York*

DEPARTMENT OF LANGUAGE AND LINGUISTIC SCIENCE
Heslington, York, YO10 5DD, UK
Phone number 07466834124
Email md738@york.ac.uk

INFORMATION SHEET

PLEASE KEEP THIS INFORMATION SHEET AND A SIGNED COPY OF THE CONSENT FORM FOR YOUR RECORDS

You are invited to take part in a research study. Before you decide whether to participate it is important for you to understand why the research is being done and what it will involve. Please take the time to read the following information carefully. If there is anything you do not understand, or if you want more information, please ask the researcher.

Title of study:
Order effects in English and Urdu speaking infants' and adults' discrimination of non-native consonants: Urdu Affricate /tʃ/-/tʃʰ/ and English approximant-fricative /w/-/v/ contrasts
Researcher: Mariam Dar

What is the research about?

This is a study related to my overall PhD. I am investigating how Urdu-speaking infants distinguish non-native speech sounds. I started out by determining which English contrasts are difficult for Urdu-speaking adults to differentiate. The Urdu contrasts which were found to be most difficult for the adults to distinguish will now be used to test infants belonging to Urdu speaking communities. Infants will be tested at 6 – 8 and 10 – 12 months of age to see at which point in time the infants' ability to distinguish non-native speech contrasts starts diminishing. The perceptual responses of the Urdu infants will be compared with English speaking infants tested in Britain.

Who is carrying out the research?

The research is being carried out by Mariam Dar, under the supervision of Professor Marilyn Vihman and Dr. Tamar Keren-portnoy of the Department of Language and Linguistic Science at the University of York.

Who can participate?
There are some restrictions as to who can participate in this study.
Your infant can participate if:
(i) He/she will be turning 6 – 8 or 10 – 12 months of age at the time of experiment.
(ii) His/her parents are a native speaker of Urdu
(iii) He/she is brought up in a household where Urdu is spoken as the main language.

What does the study involve?

The data will be collected from 6 – 8 and 10 – 12 month old infants from the Urdu speaking community. The infants will listen to Urdu speech sounds and their discriminatory abilities will be assessed through habituation-dishabituation looking procedure. The infants will be identified from the cities of Rawalpindi/Islamabad and parents will be requested to bring the infants to the babylab. You will be with your child throughout the session. The procedure will take around 20 minutes per infant.

During the procedure your child will be sitting on your lap, facing a checkerboard display. You child will be played different sounds through loudspeakers, and the length of time that they attend to the sounds will be measured. I will ask you to wear headphones playing speech sounds that make it difficult or impossible for you to hear the speech that your child is hearing. This ensures that your response will not influence your child's response in any way.

Do I have to take part?

You do not have to take part in the study. If you do decide to take part you will be given this information sheet to keep and will be asked to sign two copies of the consent form (one copy is for you to keep). If you decide to take part you will still be free to withdraw at any time without giving a reason. If you withdraw from the study, we will destroy your data in all forms and will not use it in any way.

What are the possible risks of taking part?

The study poses no foreseeable risk to you or your children. If at any stage your child becomes distressed, I will end the session.

Are there any benefits to participating?

You will be participating in an exciting new piece of linguistic research that may help linguists better understand speech perception between in infants. There has been no study to date that has analysed the way infants from Urdu speaking homes perceive non-native sounds and how it is related to later language development. There have been a few studies on English, Swedish, French and Spanish infants but no study to date has reported the pattern for Urdu infants. You will be helping the researcher to fill that gap in the field of research and also to publish a work on infants from Urdu speaking community. There will be no direct benefits to yourself, however.

I. E Consent form for Urdu infants in Study 4

Title of project: Order effects in English and Urdu speaking infants' and adults' discrimination of non-native consonants: Urdu Affricate /tʃ/-/tʃ^{h}/ and English approximant-fricative /w/-/v/ contrasts

Lead researcher: Mariam Dar

Consent form

This form is for you to state whether or not you agree to take part in the study on the behalf of your child. Please read and answer every question. If there is anything you do not understand, or if you want more information, please ask the researcher.

Have you read and understood the information leaflet about the study?	Yes □ No □
Have you had an opportunity to ask questions about the study and have these been answered satisfactorily?	Yes □ No □
Do you understands that the information provided will be held in confidence by the research team, and your child's name or identifying information about your child will not be mentioned in any publication?	Yes □ No □
Do you understand that you may withdraw your agreement to your child's taking part in the study at any time before the actual test session without giving any reason, and that in such a case all your child's data will be destroyed?	Yes □ No □
Do you understand that the information your child provide may be kept after the duration of the current project, to be used in future research on language?	Yes □ No □
Do you agree to take part in the study?	Yes □ No □
Do you understand that there will a video recording of your child's responses in the study?	Yes □ No □
Do you agree to the researcher's keeping your contact details after the end of the current project, in order that s/he may contact you in the future about possible participation of your child in other studies? *(You may take part in the study without agreeing to this).*	Yes □ No □

Your name (in BLOCK letters):

____

Email address: (Please write your email address if you want the summary of results)

____

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Your signature:
____

Researcher's name:
____

Date: ____

I.F Information Sheet for English and Urdu adults in Study 5 (with English minimal pairs)

INFORMATION SHEET

Title of research: Order effects in English and Urdu speaking infants' and adults' discrimination of non-native consonants: Urdu Affricate /tʃ/-/tʃʰ/ and English approximant-fricative /w/-/v/ contrasts

Department: Language and Linguistic Science

My name is Mariam Dar. I am a PhD student at the University of York. Feel free to contact me at any time with questions or comments relating to the study or for the results, using the contact details provided at the end of the sheet. Please read the "Questions You May Be Asking" section below before signing the consent form.

Please note: you must be 18+ years of age and you must be a native speaker of Urdu/English to participate in this study!

QUESTIONS YOU MAY BE ASKING

What is this study about?
This is a study related to my overall PhD dissertation. I am investigating how adults hear speech sounds which are present/not present in their native language. I want to determine which English speech sounds are difficult for both English and Urdu speaking adults to tell apart. Later in the study, adult responses will be compared to infants' responses to see if there is a difference between the way adults and infants hear native/non-native speech sounds.

What do I have to do?
You will be hearing different pairs of words presented by the computer and you will have to determine if words in the pair are same or different. There will be a total of 60 word contrasts. In total, the experiment may take approximately 10 minutes. Please make sure you have enough time to complete the test.

Where will the study take place?
The study will take place in the data lab, V/B/129, in Vanbrugh C block, Department of Language and Linguistic Science, University of York. The researcher will be present all the time during the experiment. A responsible third party (i.e., my supervisor/s) will also be informed of when each session will take place.

Do I have to take part?

No, participation is entirely voluntary. You are free to withdraw at any time before the end of the data collection session, and your data will be destroyed and will not be used in the research.

What kind of information do I have to give?

You will be simply asked about your name, native language and years of residence in UK which will be kept strictly confidential. You will not have to reveal any other personal details, such as home address or phone number.

What are the possible risks of taking part?

We do not expect participation in the study to involve any risks to you. If you feel uncomfortable with the procedure while you are taking part in the experiment, you can decide to withdraw from the study, even in the middle of the experimental session.

Are there any benefits to participating?

You will be participating in an exciting new piece of linguistic research that may help linguists better understand the differences in speech perception between adults and infants! There will be no direct benefits to yourself, however.

What will happen to the data I provide?

The data you provide will be used alongside the data of other participants to determine how easy or difficult it is for the participants to discriminate between the English word contrasts. The number of correct/incorrect responses and the response time will be calculated. Your data will be stored securely in the University of York, Department of Language and Linguistic Science.

What about confidentiality?

Your identity will be kept strictly confidential. No real names will be used in any presentations or publications and in the event that you email me for any reason, your email address will be securely stored and not given to anybody else.

Will I know the results?

You will be asked for an email address so that I can send you summary of the results; if you do not want to see the summary, you need not supply me with your email address. Individual results will not be available, except under special circumstances.

Contact Details:

Primary Researcher:
Mariam Dar
Department of Language and Linguistic Science
University of York
Heslington, York, UK
YO10 5DD
Email: md738@york.ac.uk

Project Supervisor:
Marilyn Vihman
Department of Language and Linguistic Science
University of York
Heslington, York, UK
YO10 5DD
Email: marilyn.vihman@york.ac.uk

The study has been reviewed and approved by the Departmental Ethics Committee of the Department of Language and Linguistic Science. If you have any questions regarding this, you can contact the head of the ethics committee, Traci Walker, email: tsc3@york.ac.uk. Telephone: 01904 323611.

I.G Information Sheet for English and Urdu adults in Study 5 (with Urdu minimal pairs)

INFORMATION SHEET

Title of research: Order effects in English and Urdu speaking infants' and adults' discrimination of non-native consonants: Urdu Affricate /tʃ/-/tʃʰ/ and English approximant-fricative /w/-/v/ contrasts

Department: Language and Linguistic Science

My name is Mariam Dar. I am a PhD student at the University of York. Feel free to contact me at any time with questions or comments relating to the study or for the results, using the contact details provided at the end of the sheet. Please read the "Questions You May Be Asking" section below before signing the consent form.

Please note: you must be 18+ years of age and you must be a native speaker of Urdu/English to participate in this study!

QUESTIONS YOU MAY BE ASKING

<u>What is this study about?</u>
This is a study related to my overall PhD dissertation. I am investigating how adults hear speech sounds which are present/not present in their native language. I want to determine which Urdu speech sounds are difficult for both English and Urdu speaking adults to tell apart. Later in the study, adult responses will be compared to infants' responses to see if there is a difference between the way adults and infants hear native/non-native speech sounds.

<u>What do I have to do?</u>
You will be hearing different pairs of words presented by the computer and you will have to determine if words in the pair are same or different. There will be a total of 48 word contrasts. In total, the experiment may take approximately 10 minutes. Please make sure you have enough time to complete the test.

<u>Where will the study take place?</u>
The study will take place at your home. The researcher will be present all the time during the experiment. A responsible third party (i.e., my supervisor/s) will also be informed of when each session will take place.

Do I have to take part?

No, participation is entirely voluntary. You are free to withdraw at any time before the end of the data collection session, and your data will be destroyed and will not be used in the research.

What kind of information do I have to give?

You will be simply asked about your name, native language and years of residence in Pakistan which will be kept strictly confidential. You will not have to reveal any other personal details, such as home address or phone number.

What are the possible risks of taking part?

We do not expect participation in the study to involve any risks to you. If you feel uncomfortable with the procedure while you are taking part in the experiment, you can decide to withdraw from the study, even in the middle of the experimental session.

Are there any benefits to participating?

You will be participating in an exciting new piece of linguistic research that may help linguists better understand the differences in speech perception between adults and infants! There will be no direct benefits to yourself, however.

What will happen to the data I provide?

The data you provide will be used alongside the data of other participants to determine how easy or difficult it is for the participants to discriminate between the Urdu word contrasts. The number of correct/incorrect responses and the response time will be calculated. Your data will be stored securely in the University of York, Department of Language and Linguistic Science.

What about confidentiality?

Your identity will be kept strictly confidential. No real names will be used in any presentations or publications and in the event that you email me for any reason, your email address will be securely stored and not given to anybody else.

Will I know the results?

You will be asked for an email address so that I can send you summary of the results; if you do not want to see the summary, you need not supply me with your email address. Individual results will not be available, except under special circumstances.

Contact Details:
Primary Researcher:
Mariam Dar
Department of Language and Linguistic Science
University of York
Heslington, York, UK
YO10 5DD
Email: md738@york.ac.uk

Project Supervisor:
Marilyn Vihman
Department of Language and Linguistic Science
University of York
Heslington, York, UK
YO10 5DD
Email: marilyn.vihman@york.ac.uk

The study has been reviewed and approved by the Departmental Ethics Committee of the Department of Language and Linguistic Science. If you have any questions regarding this, you can contact the head of the ethics committee, Traci Walker, email: tsc3@york.ac.uk. Telephone: 01904 323611.

I.H Consent Form for English & Urdu adults in Study 5

Title of project: Order effects in English and Urdu speaking infants' and adults' discrimination of non-native consonants: Urdu Affricate /tʃ/-/tʃʰ/ and English approximant-fricative /w/-/v/ contrasts

Lead researcher: Mariam Dar

Consent form

This form is for you to state whether or not you agree to take part in the study. Please read and answer every question. If there is anything you do not understand, or if you want more information, please ask the researcher.

Have you read and understood the information leaflet about the study?	Yes ☐ No ☐
Have you had an opportunity to ask questions about the study and have these been answered satisfactorily?	Yes ☐ No ☐
Do you understands that the information provided will be held in confidence by the research team, and your name or identifying information about you will not be mentioned in any publication?	Yes ☐ No ☐
Do you understand that you may withdraw your agreement to you taking part in the study at any time before the actual test session without giving any reason, and that in such a case all your data will be destroyed?	Yes ☐ No ☐
Do you understand that the information you provide may be kept after the duration of the current project, to be used in future research on language?	Yes ☐ No ☐
Do you agree to take part in the study?	Yes ☐ No ☐
Do you agree to the researcher's keeping your contact details after the end of the current project, in order that s/he may contact you in the future about possible participation in other studies? *(You may take part in the study without agreeing to this).*	Yes ☐ No ☐

Your name (in BLOCK letters): ____

Email address: ____

Your signature: ____

Researcher's name: ____

Date: ____

APPENDIX II: URDU MINIMAL PAIRS FOR ADULT PILOT

	Words	**Meanings**	**Words**	**Meanings**
1	pɑl	Moment	pʰɑl	Fruit
2	pʊr	to fill up	pʰʊr	to go away quickly
3	bɑr	Husband	bʱɑr	to fill up
4	baɪ	Maid	bʱaɪ	Brother
5	kɑ:l	Shortage	kʰɑ:l	Skin
6	kɑ:t	to cut	kʰɑ:t	Bed
7	gɑr	If	gʱɑr	House
8	gaʊl	Round	gʱaʊl	Stur
9	d̪ɑr	Door	d̪ʱɑr	to put
10	d̪aʊ	Two	d̪ʱaʊ	to wash
11	t̪ɑl	to fry	t̪ʰɑl	to fill up
12	t̪ɑk	Till	t̪ʰɑk	Tired
13	ʈɑ:l	Postpone	ʈʰɑ:l	lumber shop
14	ʈɑ:ʈ	Maat	ʈʰɑ:ʈ	Luxury
15	ɖɑ:l	Branch	ɖʱɑ:l	Protection
16	tʃɑ:l	Trick	tʃʰɑ:l	tree bark
17	tʃʊp	to be silent	tʃʰʊp	to hide
18	dʒaʊnk	Termite	dʒʱaʊnk	to push
19	dʒɑ:l	Net	dʒʱɑ:l	Glimmer
20	bəɽɑ	Big	bəɽʱɑ	to increase
21	pət̪ɑ	Address	pət̪:ɑ	Leaf
22	gəd̪ɑ	Mace	gəd̪:ɑ	Mattress
23	bətʃɑ	Save	bətʃ:ɑ	Child
24	pəʈɑ	to make someone	pəʈ:ɑ	to fold

		agree		
25	pəkɑ	to cook	pək:ɑ	Firm

APPENDIX III: ADULT STUDY

III.A Urdu minimal pairs for adult study

	tʃ-first words	**Meaning**	**tʃʰ-first words**	**Meaning**
1	tʃa:l	Gait	tʃʰa:l	Outer skin
2	tʃa:p	Footsteps	tʃʰa:p	Influence
3	tʃak	Bite	tʃʰak	Sound of a train
4	tʃal	Go	tʃʰal	To betray
5	tʃoti	Small hill	tʃʰoti	Small
6	tʃiɽna	Get irritated	tʃʰiɽna	Get started
7	tʃi:n	China	tʃʰi:n	To snatch
8	tʃoũn	To complain	tʃʰoũn	A type of sound
9	tʃour	Thief	tʃʰouɽ	Let go
10	tʃʊp	Quiet	tʃʰʊp	To hide
11	tʃupkay	Quietly	tʃʰupkay	Stealthily
12	tʃu:na	Chalk	tʃʰu:na	To touch

III.B English minimal pairs for Adult study

	w-first words	v-first words
1	West	Vest
2	Wine	Vine
3	Wiper	Viper
4	Wail	Veil
5	Worse	Verse
6	Went	Vent
7	Wary	Very
8	Woe	Voe
9	Wet	Vet
10	Wan	Van
11	Wane	Vane
12	Wick	Vic
13	Wiser	Visor
14	Walt	Vault
15	Weal	Veal

APPENDIX IV: URDU WORDS FOR /W/-/V/ ALLOPHONY ANALYSIS

	Words	Urdu Spellings	Context	Meaning
1	**ʋɛrdı**	وردی	Word-initial	Uniform
2	**ʋəkt**	وقت	Word-initial	Time
3	**ʋoh**	وہ	Word-initial	This
4	**ʋadʒə**	وجہ	Word-initial	Reason
5	**ʋa:kjə**	واقعہ	Word-initial	Incident
6	**ʋarıs**	وارث	Word-initial	Heir
7	**ʋohı**	وہی	Word-initial	That
8	**pakʋa:n**	پکوان	Syllable-initial	Food
9	**ʋa:la**	والا	Word-initial	A bound morpheme indicating masculinity
10	**ʋa:lı**	والی	Word-initial	A bound morpheme indicating femininity
11	**perʋana**	پروانا	Syllable-initial	Moth
12	**ʋa:da**	وعدا	Word-initial	Promise
13	**ʋera:n**	ویران	Word-initial	Isolated
14	**ʋadi**	وادی	Word-initial	Valley
15	**ʋah**	واہ	Word-initial	Wow
16	**ʋalıd**	والد	Word-initial	Father
17	**ʋapəs**	واپس	Word-initial	To return
18	**ʋizarət**	وزارت	Word-initial	Presidency
19	**ʋɛhmi**	وہمی	Word-initial	Doubtful
20	**ʋehʃi**	وہشی	Word-initial	Wild
21	**ʋklə**	وکلا	Word-initial	Lawyers
22	**sʋa:bi**	صوابی	Followed by word-initial consonant	Name of city in Pakistan
22	**ʋırasət**	وراثت	Word-initial	Inheritance
23	**ʋo:ʈ**	وُٹ	Word-initial	Vote

APPENDIX V: URDU/HINDI PHONEMIC SYSTEM

The variety described here is the standard Urdu used in everyday casual speech by educated speakers in cities such as Islamabad, Lahore etc. Although there are differences in pronunciation among speakers of different cities, the differences are minimal. In comparison with English Urdu has approximately half as many vowels and twice as many consonants. The major Phonemic differences are presented below (Table 1).

Table 1 Urdu/Hindi consonant inventory

Plosive	**p b** **p^h b^h**		**t̪ d̪** **$t̪^h$ $d̪^h$**			**ʈ ɖ** **$ʈ^h$ $ɖ^h$**		**k g** **k^h g^h**	**ʔ**	
Affricate					**tʃ $tʃ^h$** **dʒ $dʒ^h$**					
Nasal	**m**		**n̪**			**ɳ**	**ɲ**	**ŋ**		
Fricative		**f v**		**s z**	**ʃ**			**χ** **ɣ**	**h**	**q**
Approximant				**r**		**ɽ**	**j**			
Lateral Approximant				**l**		**ɭ**				

1. Plosives

The plosive sounds in English /p t k/ (voiceless) and /b d g/ (voiced) have voicing contrast, whereas in Urdu there is an additional contrast of aspiration. The examples are resented in the Table 2 below:

Table 2 Plosives in Urdu/Hindi

Urdu	IPA	Gloss
پل	pal	*'moment'*
پھل	pʰal	*'fruit'*
بورا	bʊɾa	*'powder'*
بھورا	bʰʊɾa	*'brown'*
تک	tak	*'stare'*
تھک	tʰak	*'get tired'*
دعوا	dava	*'legal action'*
دھوا	dʰava	*'an attack'*
کل	kal	*'tomorrow'*
کھل	kʰal	*'hide'*
گرا	giɾa	*'to fall'*
گھرا	gʰiɾa	*'surrounded'*

2. Affricates

In Urdu there are four affricates /tʃ/, /tʃʰ/, /dʒ/, /dʒʰ/ which contrast in voice and aspiration. Some examples are presented in Table 3.

Table 3 Affricates in Urdu/Hindi

Urdu	IPA	Gloss
جال	dʒala	*'web'*
جھال	dʒʰala	*'resonance'*
چال	tʃa:l	*'gait'*
چھال	tʃʰa:l	*'outer skin of the tree'*

3. Retroflex

One of the major characteristics of Urdu/Hindi and especially most of the Indo-Aryan, Dravidian and Munda languages is the occurrence of retroflex consonants (Kaye, 1997). The retroflex phonemes are /ʈ, ʈʰ, ɖ, ɖʰ, ɽ, ɽʰ/. Some of the examples are given in Table 4.

Table 4 Retroflex sounds in Urdu/Hindi

Urdu	IPA	Gloss
گاڑی	gaɽɪ	*'car'*
گاڑھی	gaɽ^{h}ɪ	*'thick'*
ڈور	ɖor	*'rope'*
گڈا	guɖɖa	*'doll'*
ٹاٹ	ʈaʈ	*'mat'*
ٹھاٹ	ʈ^{h}aʈ	*'pomp'*

The retroflexes /ʈ/ and /ʈ^{h}/ occur in word-initial, medial and word-final positions. However, the retroflexes /ɖ/ and /ɖ^{h}/ rarely occur in positions where the flaps [ɽ] and [ɽ^{h}] occur. The flaps /ɽ/ and /ɽ^{h}/ occur i) between vowels and ii) adjacent to a non-retroflex consonant where /ɖ/ and /ɖ^{h}/ do not occur. In contrast, /ɖ/ and /ɖ^{h}/ occur i) initially ii) after a retroflex consonant and iii) before a semivowel where /ɖ/ and /ɖ^{h}/ do not occur (See Figure 1). Because of this non-contrastive distribution [ɖ, ɖ^{h} ɽ ɽ^{h}] are sometimes treated as allophones of the same phoneme.

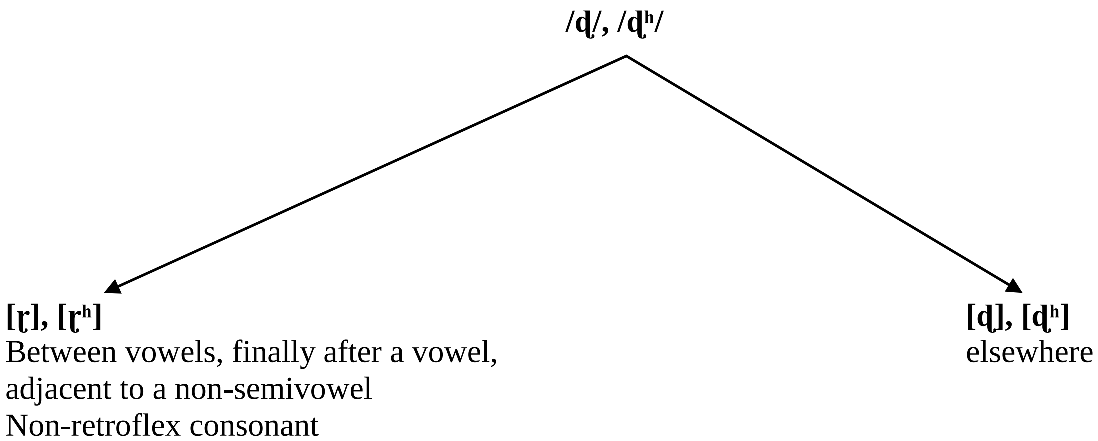

Figure 1 Allophonic distribution of retroflexes in Urdu/Hindi

However, in a few words of mostly Sanskrit and foreign origin /ɖ/ and /ɖʰ/ occur in positions reserved for the flaps /ɽ/ and /ɽʰ/. Those foreign and new native words can be looked upon as the exceptions to the general phonological rule. Also, there is contrastive distribution between /t/ and /ʈ/ and all other retroflex and non-retroflex pairs: [ata] 'to come' vs. [aʈa] 'whole grain flour; [vo da:l hɛ]]'that is lentil' vs. [vo ɖa:l hɛ] 'that is the branch'; [bəɾ] 'suitable groom' and [bəɽ bəɽ] 'to mumble'

4. Nasals

Urdu has unaspirated as well as aspirated nasals: /n̪, ɲ, ɳ, ŋ, m, ɱ, mʰ and nʰ/. The phoneme /n̪/ has three variants [n], [ɲ] and [ŋ]. This dental nasal /n̪/ appears not only the before the dental consonants, /t/, /tʰ, /d/, /dʰ/, and /s/ but also next to a vowel. The assimilation of the dental nasal [n̪] is presented in Figure 2.

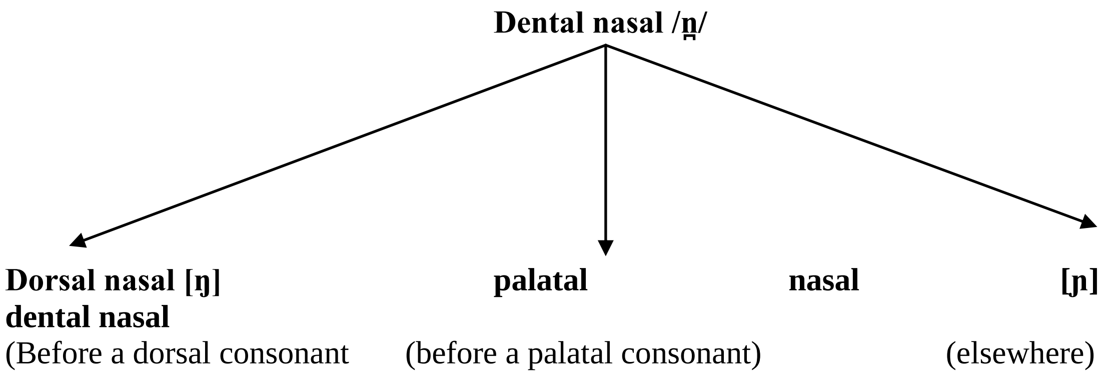

Figure 2 Allophonic distribution of Dental nasal in Urdu/Hindi

A few examples are presented in Table 5;

Table 5 Nasal sounds in Urdu/Hindi

Urdu	IPA	Gloss
سنگ	saŋg	*'coming together'*
ہنس	hans	*'goose'*
پنچھی	paɲtʃʰɪ	*'bird'*

The retroflex nasal /ɳ/ does not occur initially. Rather, it occurs only medially between vowels and finally. In most cases, however, it occurs before a homographic retroflex stop and loses its flap quality (Table 6).

Table 6 How retroflex nasal occurs in a word in Urdu/Hindi

Urdu	IPA	Gloss
گھنٹہ	gʰaɳʈa	*'hour'*
انڈہ	aɳɖa	*'egg'*

5. The uvular and glottal stops /q/ and ?

Some speakers utilize a voiceless uvular stop /q/, which occurs in words of Arabic origin, and since it contrasts with other obstruents, it is a phoneme. In their everyday speech however, the uvular /q/ is replaced by the phonetically similar velar /k/. The contrasting pairs for /q/ and /k/ are presented in Table 7.

Table 7 Uvular and glottal in Urdu/Hindi

Urdu	IPA	Gloss
قصائ	qasaı	*'butcher'*
کسائی	kasaı	*'tightening'*
مقرر	Muqarar	*'fixed'*
مکرر	Mukarar	*'a second time'*

The glottal stop ? is pronounced by a few Urdu scholars and preachers in the words borrowed from Arabic but others simply drop it. The glottal stop ? contrasts with similar words as shown in Table 8.

Table 8 How glottal stop ? contrasts with words in Hindi/Urdu

Urdu	IPA	Gloss
عمل	?amal	*'act'*
امل	Amal	*'a girl's name'*
عام	?ãm	*'common'*
آم	Ãm	*'Mango'*
کام	Kãm	*'work'*

6. The fricatives ɣ and χ

In Urdu, the fricatives /χ ɣ/ are not as common as the other fricatives /f v s z/ but they occur in all positions: word-initially, medially and word-final. It is also /common for Urdu speakers to substitute the phonetically similar affricates /k/ and /g/ for the fricatives /χ/ and /ɣ/ respectively. A few examples are presented in Table 9.

Table 9 The fricatives ɣ and χ in Urdu/Hindi

Urdu	IPA	Gloss
خم	Xam	*'bend, curve'*
غم	ɣam	*'sadness'*
شاخ	ʃaχ	*'branch'*
داغ	daɣ	*'stain'*

7. Gemination

In Urdu consonants can occur in relatively longer or shorter forms. All consonants can occur with distinctive length except /bʰ, ɽ, ɽʰ, h, f/. Geminates occur only word medially preceded by non-peripheral vowels [ɪ ə ʊ]. See Table 10 for examples.

Table 10 Gemination in Urdu/Hindi

Urdu	IPA	Gloss
ٹھپہ	ʈʰəp:a	*‘stamp’*
ڈبہ	ɖəb:a	*‘box’*
پلہ	pəl:a	*‘shawl’*
اماں	əm:a	*‘mother’*
رسہ	rəs:a	*‘a heavy rope’*
اول	əv:al	*‘first’*
کتا	Kʊt:a	*‘dog’*
بننا	bʊn:a	*‘weave’*

Although the orthography distinguishes geminated consonants in final position like [ɾabb] ‘God’, they are pronounced as singletons. There are also some free variants involving geminates i.e. Delhi (name of a city) can be [dɪl:i] or [dəhli] and the interjection ‘Oh’ can be [əʊh:əʊ] or [əʊhəʊ]. English does not have any geminates.

8. The dental and retroflex lateral [l] and [ɭ]

In Urdu the lateral phoneme /l/ has two allophones: a retroflex lateral [ɭ] before a retroflex stop and a dental lateral [l] elsewhere (Figure 3).

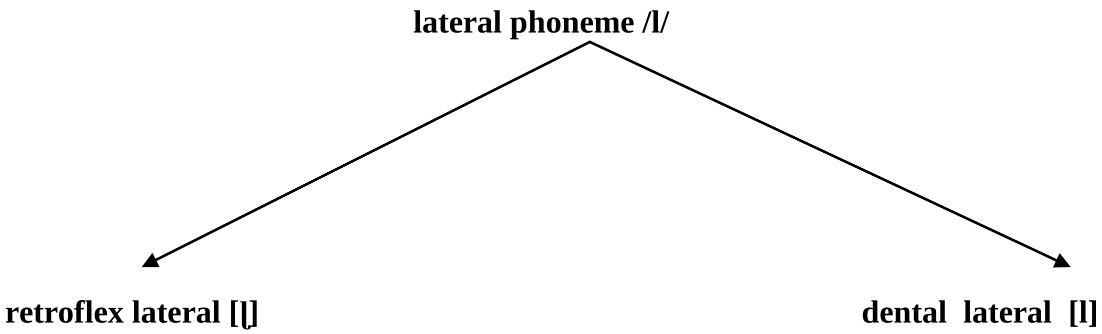

Figure 3 Allophonic distribution of lateral phoneme /l/ in Urdu/Hindi

A few examples are presented in the Table 11

Table 11 Laterals in Urdu/Hindi

Urdu	IPA	Gloss
الٹا	uɭʈa	*'reversed'*
ڈالڈا	ɖaɭɖa	*'a cooking oil'*
ڈالتا	ɖalta	*'put something in'*

APPENDIX VI: ACOUSTIC MEASURES OF STIMULI

VI.A Acoustic measures of stimuli in Study 1 & 2

tʃʊp	*Max Amplitude*	*Mean Amplitude*	*Max F0*	*Minimum F0*	*Mean F0*	*Range F0*	*Duration*
S1	69.777	66.545	300.663	267.956	288.594	32.707	0.239
S2	71.214	68.618	303.245	276.559	288.906	26.686	0.245
S3	72.313	69.39	305.116	280.915	292.454	24.201	0.249
S4	72.847	70.274	309.777	286.718	296.549	23.059	0.253
S5	73.486	70.969	311.09	288.268	297.16	22.822	0.256
S6	74.018	71.874	308.467	285.691	298.581	22.776	0.257
Average	72.275	69.611	306.393	281.017	293.707	25.375	0.249
SD	1.562	1.889	4.054	7.712	4.348	3.886	0.006

tʃʰʊp	*Max Amplitude*	*Mean Amplitude*	*Max F0*	*Minimum F0*	*Mean F0*	*Range F0*	*Duration*
S1	71.214	68.406	300.405	270.949	281.627	29.456	0.439
S2	71.401	68.437	308.168	281.232	286.879	26.936	0.452
S3	72.224	69.182	316.554	272.649	290.877	43.905	0.453
S4	72.291	69.564	319.112	284.831	298.55	34.281	0.472
S5	72.657	69.905	323.697	290.271	304.088	33.426	0.49
S6	73.061	70.28	311.044	287.352	299.406	23.692	0.499
Average	72.141	69.296	313.163	281.214	293.571	31.949	0.4675

VI.B Acoustic measures of stimuli in Study 3

tʃa:l	***Max Amplitude***	***Mean Amplitude***	***Max F0***	***Minimum F0***	***Mean F0***	***Range F0***	***Duration***
S1	76.767	70.168	258.789	116.659	204.606	142.13	0.627
S2	77.714	70.075	268.057	112.484	202.117	155.573	0.649
S3	78.648	71.438	267.184	115.018	209.309	152.166	0.658
S4	78.399	71.174	270.475	112.178	200.854	158.297	0.636
S5	71.084	66.433	255.594	115.793	189.568	139.801	0.629
S6	73.319	67.834	260.544	109.223	191.333	151.321	0.628
Average	*75.9885*	*69.520*	*263.440*	*113.559*	*199.631*	*149.881*	*0.638*
SD	*3.087*	*1.975*	*5.939*	*2.778*	*7.697*	*7.378*	*0.012*
tʃa:l	***Max Amplitude***	***Mean Amplitude***	***Max F0***	***Minimum F0***	***Mean F0***	***Range F0***	***Duration***
S1	75.319	69.985	261.536	117.219	196.567	144.317	0.556
S2	75.182	70.039	261.004	118.388	197.243	142.616	0.547
S3	78.073	71.82	258.645	113.871	199.787	144.774	0.537
S4	77.887	71.628	263.653	119.646	200.612	144.007	0.581
S5	78.377	71.773	270.413	112.176	200.757	158.237	0.561
S6	71.92	66.872	260.033	118.08	190.841	141.953	0.52
Average	*76.126*	*70.352*	*262.548*	*116.563*	*197.634*	*145.984*	*0.5503*
SD	*2.498*	*1.905*	*4.196*	*2.900*	*3.760*	*6.097*	*0.0209*

VI.C: Acoustic measures of stimuli in Study 4

vaɪn	**Max amplitude**	**Mean amplitude**	**Max F0**	**Minimum F0**	**Mean F0**	**Range F0**	**Duration**
S1	74.693	65.339	251.458	120.774	184.782	130.684	0.922
S2	71.625	65.492	265.088	113.796	193.284	151.292	0.892
S3	70.495	66.333	254.644	127.366	176.748	127.278	0.915
S4	74.66	62.295	238.107	120.788	183.612	117.319	0.93
S5	75.353	65.564	236.409	116.703	184.585	119.706	0.855
S6	75.35	65.512	240.674	117.975	185.231	122.699	0.87
Average	*73.696*	*65.089*	*247.73*	*119.567*	*184.707*	*128.163*	*0.897*
SD	*2.095*	*1.413*	*11.257*	*4.643*	*5.261*	*12.337*	*0.030*
waɪn	**Max amplitude**	**Mean amplitude**	**Max F0**	**Minimum F0**	**Mean F0**	**Range F0**	**Duration**
S1	78.135	69.07	251.609	118.803	190.371	132.806	0.861
S2	77.483	69.128	250.138	115.224	183.006	134.914	0.862
S3	74.819	65.55	238.724	112.017	180.139	126.707	0.863
S4	73.574	65.552	256.424	117.667	187.888	138.757	0.853
S5	74.811	65.582	243.567	116.036	180.301	127.531	0.82
S6	73.584	65.342	256.8	110.092	186.368	146.708	0.859
Average	*75.401*	*66.704*	*249.544*	*114.973*	*184.679*	*134.570*	*0.853*

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