NATIVE ENGLISH SPEAKERS' PRODUCTION OF ITALIAN /t/: THE EXTENT OF PHONETIC LEARNING IN ADULT SECOND LANGUAGE ACQUISITION AND THE EFFECT OF NATIVE SPEAKER INPUT

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Abstract

This study examines the production of Italian /t/ by native English participants who began acquiring Italian as adults. It investigates the extent of phonetic learning in Italian /t/ for individuals who have been living in Italy for many years (late bilinguals) and the effect of quantity of native speaker input on phonetic learning in Italian /t/ for the late bilinguals and three groups of students who differ in terms of amount of received exposure to native Italian speech. In addition, it investigates whether phonetic learning in Italian /t/ coincides with modifications to the way in which English /t/ is produced. Voice-onset time (VOT), burst amplitude and closure duration were measured in English and Italian monolingual productions of /t/ in order to establish phonetic norms. Only VOT exhibited enough variation to be used as an indicator of phonetic learning. Late bilinguals showed partial phonetic learning in the form of compromise values which were intermediate to English and Italian monolingual VOT. Phonetic learning in student realisations of Italian /t/ increased in line with amount of received native speaker input. Contrastingly, the late bilinguals did not display the most phonetic learning, despite having received the most native speaker input. It was proposed that native speaker input influences phonetic learning in the early stages of acquisition, but that phonetic learning for the late bilinguals had fossilised. In the later stages of acquisition, age of learning (AOL) was deemed to be a more accurate predictor of phonetic learning than input. Neither the late bilinguals, nor the students exhibited modifications to VOT in their English realisations of /t/ which may have occurred as a result of a lack of plasticity in the L1 phonetic system, or a high level of L1 use in participants' daily lives.

1. Introduction

Phonetic learning occurs in second language acquisition (SLA) when individuals produce sounds which occur in a second language (L2) that are either not present in their first language (L1), or are realised in a different way from a corresponding L1 sound (Flege, 1991; MacKay et al., 2001). Complete phonetic learning in the form of native-like values is rarely achieved in adult SLA (Major, 1994: 12; Flege, 1995: 233). However, partial phonetic learning is frequently observed when L2 sounds are produced with values which differ from corresponding L1 sounds, as individuals acquire L2 sounds with values which approach that of target L2 sounds (Flege 1987, 1991). This results in the production of L2 sounds with "compromise values" (Flege, 1991: 396) which are intermediate to L1 and L2 monolingual values.

Phonetic learning in adult SLA has been observed to coincide with modifications to how the corresponding sound is produced, which takes on characteristics of the L2 sound (Flege, 1987; Major, 1987, 1994; MacKay et al., 2001) This indicates that the adult L1 phonetic system employed in the production and perception of L2 sounds is reorganised in order to permit production of L2 sounds which are more native-like, resulting in

changes to pronunciation of the corresponding L1 sound.

The present study is linked to a large body of research investigating the capacity of adults to achieve native-like pronunciation in a second language. Its aim is to determine to what extent native English speakers who have been living in Italy for many years (late bilinguals[1]) exhibit phonetic learning in the production of Italian voiceless plosive /t/. In addition, it aims to identify whether quantity of received native speaker input influences phonetic learning between groups of native English speakers who differ in terms of years of learning and weekly exposure to native Italian speakers. More specifically, the first part of this investigation seeks to address whether late English-Italian bilinguals show evidence of phonetic learning in their production of word-initial Italian /t/, and if so whether this is partial in the form of compromise values as observed in previous studies, or complete in the form of native speaker values. The second question addressed by this study is whether phonetic learning in word-initial /t/ increases in accordance with increased levels of received native speaker input, namely, whether groups who have received more exposure to native Italian speech exhibit more phonetic learning than groups who have received less. In addition, both parts of this investigation aim to explore the influence of phonetic learning in L2 on the pronunciation of corresponding sounds in L1. The third question addressed in this study, therefore, is whether phonetic learning in Italian /t/ coincides with modifications to the way in which English /t/ is produced for native English speakers acquiring Italian, and whether this is influenced by amount input received by native Italian speakers.

2. Research context

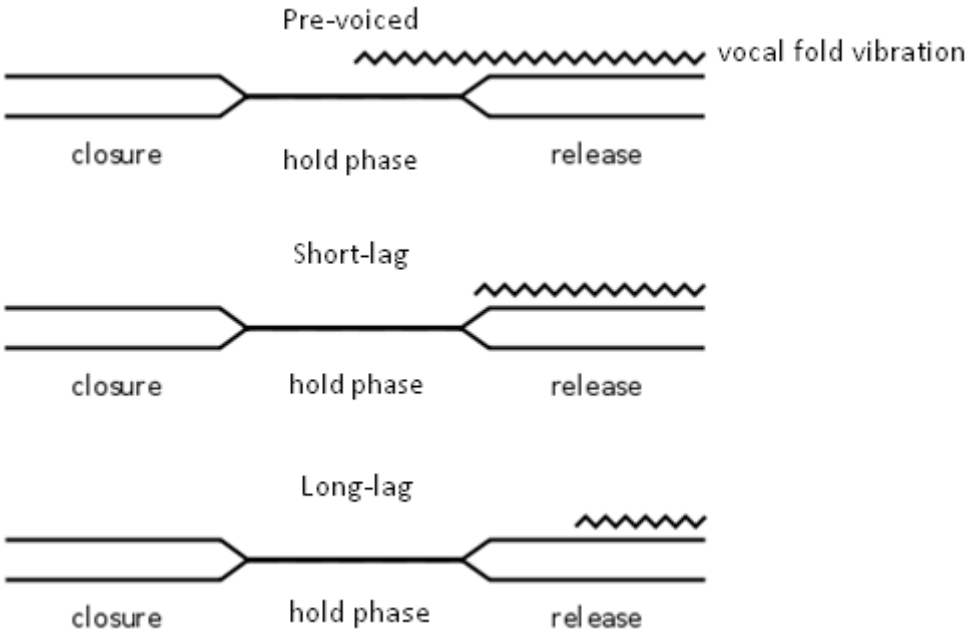
Research examining stop consonants in L1 and L2 which are "similar" (Flege, 1991: 396) due to shared articulatory, acoustic and phonological attributes, but which differ in terms of phonetic cues, indicates that individuals who acquire an L2 in late adolescence or adulthood (henceforth referred to as adults) do not reproduce phonetic differences in L2 with native-like L2 values (Caramazza et al., 1973; Major, 1987, 1994; Flege, 1991; Thornburg & Ryalls, 1998; MacKay *et al* 2001). It is hypothesised that articulatory, acoustic and phonological similarities cause "perceptual linkage" in which individuals identify L2 sounds with existing L1 sounds, inhibiting native-like processing of the phonetic differences which separate L2 sounds from their L1 counterparts (MacKay et al., 2001: 516). For example /t/ in Romance languages such as Spanish, Italian and French has been shown to be perceptually linked to /t/ in Germanic languages such as English and German (Caramazza et al., 1973; Williams, 1977; Bohn & Flege, 1990; Grasseger, 1991 in Llisterri, 1995; Kehoe et al., 2004; Mackay et al., 1999), yet they differ in terms of the phonetic cues which delineate the voiced-voiceless phonological distinction. In addition to others, these include VOT (Ladefoged, 2001: 137), closure duration and burst amplitude (Lisker & Abramson, 1964: 385), although closure duration and burst amplitude have been shown to vary less systematically than VOT (Butcher, 2004; Kehoe et al., 2004). Studies focusing on the production of phonologically voiceless /t/ tokens which are prone to be identified with one another in Romance and Germanic languages indicate that adults frequently do not fully realise cross-linguistic phonetic variation between these sounds (Major, 1987, 1994; Flege, 1991). The following section introduces the research context concerning adult phonetic learning in L2 sounds which

correspond to existing L1 sounds. It presents a review of previous research examining phonetic variation between Romance and Germanic languages, perceptual linkage between similar sounds, the capacity of the adult brain to acquire L2 sounds and its effect on L1 and finally the influence of input on adult phonetic learning.

2.1 Cross-linguistic variation of stop consonants: voicing contrasts and place of articulation

Italian and English implement a phonological distinction between voiced (/b d g/) and voiceless (/p t k/) stop consonants. The voicing distinction in syllable initial stops uses VOT as its primary phonetic cue (Kent & Read, 1992: 120; Lisker & Abramson, 1964). VOT refers to the temporal relationship between the release of a stop consonant and the onset of vocal fold vibration (voicing) and is measured as the amount of time in ms which transpires between these two articulatory events. This continuous dimension is divided into three main categories: prevoiced, a negative VOT value in which voicing starts before the release of the stop; short-lag, in which voicing starts at the same time as, or within about 35ms after the stop is released; and long-lag, in which the onset of voicing occurs more than 35ms after the stop is released (Keating, 1984: 295) – see Figure 1. Stop consonants vary cross-linguistically in terms of which of the possible three VOT categories are assigned to the two phonological classes which constitute the voiced-voiceless distinction (Cho & Ladefoged, 1999: 207). For example, in Germanic languages short-lag stop consonants are contrasted phonemically with long-lag stop consonants as voiced and voiceless respectively, whereas Romance languages implement a phonological contrast between pre-voiced stop consonants and short-lag stop consonants as voiced and voiceless respectively. Consequently, voiceless stops are produced with long-lag VOT in Germanic languages and short-lag VOT in Romance languages. This cross-linguistic variation results in shorter VOT values in Italian /t/ with respect to that of English /t/ (Nespor, 1993: 55).

Figure 1. The temporal relationship between vocal fold vibration and closure release in stop consonants.



It is often noted that differences in VOT between short-lag and long-lag stop consonants coincide with variations in other acoustic parameters (Hardcastle, 1973). These include, amongst others, the loudness of the release burst (burst amplitude) and the period of time for which the active and passive articulators are held together (closure duration) (Halle et al., 1957: 107; Fry, 1979: 125; Stevens & Keyser, 1989: 93; Kent & Read, 1992: 112, 110; Johnson, 1988: 131). These features are often grouped together into single correlates as "tense", which includes long-lag VOT, longer closure duration and a louder release burst, and "lax" which includes short-lag VOT, shorter closure duration and a quieter release burst (Hardcastle, 1973). The single correlate which separates tense and lax stops has been described as "phonetic power" with tense stops involving more muscular tension and a higher level of pressure in the vocal tract than lax stops (Kohler, 1984: 169).

However, a review of previous research indicates that these features do not always vary in conjunction with each other. For example, Jaegre (1983) states that long closure duration is a key characteristic of tense stops whereas Kohler (1984: 164) associates long closure duration with lax stops. In addition, the closure duration parameter has been found to vary according to language, stress and utterance position (Lisker, 1972; Kohler, 1984: 164). In the absence of systematic correlation, categorising various phonetic parameters as a single correlate is often considered to be an inadequate way of accounting for phonetic variation which Catford (1977: 203) describes as being in need of "precise phonetic specification". In line with the notion that phonetic parameters such as closure duration and burst amplitude do not always vary systematically with VOT, Butcher (2004) identified minimal differences between closure duration and intra-oral air pressure (a correlate of burst amplitude) in Italian and English realisations of voiceless stop /p/. However, relatively few studies have investigated variation of phonetic cues other than VOT between plosives in Italian and English and as a result it remains unclear whether closure duration and burst amplitude are accurate predictors of cross-linguistic contrasts between Italian and English /t/.

In contrast, place of articulation (POA) has been shown to vary systematically between Italian and English. English /t/ is frequently articulated with contact between the tongue tip and the alveolar ridge (laminal alveolar) whilst Italian /t/ is formed with the tongue blade against the back of the front teeth (apical dental) (Major, 1994: 184). Variation in POA is measured most effectively through the use of electropalatography (Payne, 2005) as information regarding place of articulation is generally unavailable through acoustic measurements (Ladefoged, 2003: 160). This study focuses on a selection of the differences which are possible to measure acoustically, namely VOT, closure duration and burst amplitude. Consequently the current investigation will not investigate differences in POA.

2.2 The role of equivalence classification in adult SLA

2.2.1 ‘New’ and ‘similar’ phones

Adult success in achieving native proficiency in the production of L2 sounds has been

observed to vary as a result of the L2 sound's articulatory, acoustic and phonological relationship with existing sounds in the L1 phonetic inventory (Flege, 1987). For example, in a comparison of 'new' and 'similar' phones in French and English, Flege (1987) found that native English speakers highly experienced in French were able to produce French vowel /y/ which is considerably different to any sound in English (new) with values equivalent to native French speakers. In contrast, the vowel /u/, which is considered 'similar' due to its close relationship with English /u/ was not acquired with native proficiency. Productions of French /u/ exhibited influence from English as even the most experienced participants failed to produce French /u/ with native French formant values producing it with a higher F2 frequency which is characteristic of English /u/. This is consistent with a long line of research which shows that adults tend not to achieve native-like values in the production of an L2 speech sound which has a phonological counterpart in L1 with similar but not identical acoustic characteristics (Caramazza et al., 1973; Major, 1987, 1994; Flege, 1991; Thornburg & Ryalls, 1998; MacKay et al., 2001).

A possible explanation for this phenomenon is the notion of "similarity" (Wode, 1981; Young-Scholten, 1985; Flege, 1995) which proposes that L2 sounds which are articulatorily, acoustically and phonologically similar to L1 sounds are less likely to be produced accurately than those which are dissimilar. In Flege's speech learning model (1995) the difference in the acquisition of "new" and "similar" phones is accounted for by the "equivalence classification" hypothesis, which is based on the notion that in order to produce an L2 sound with native-like values the L1 phonetic system must add a new category with which to process it. In SLA, equivalence classification refers to instances in which similarities between L1 and L2 sounds cause them to be perceptually identified with one another. Flege (1995: 239) hypothesises that if phonetic differences are perceived as "distinct", new categories will be added to the L1 phonetic system for the purpose of processing the new L2 sound. This accounts for the accuracy with which adults produce sounds which are considerably different to existing L1 sounds (Flege, 1987) However, if L1 and L2 sounds are identified with one another through the mechanism of equivalence classification, adults process the L2 sound with an existing L1 category. Consequently, equivalence classification prevents the addition of a new phonetic category thus inhibiting native-like production of the perceptually linked L2 sound.

One of the problems with this notion is the definition of the term "similar". This is due to the problematic nature of measuring the perceptual relationship between L1 and L2 sounds in SLA. As Flege (1995:264) notes, there is no objective method with which to determine perceived phonetic similarities and differences. This difficulty is partially overcome with reference to studies such as Bohn & Flege (1990) and Williams (1977) in which listeners identify tokens of English [t^h] and Spanish [t] as allophones of /t/, as it is assumed that the sounds must be similar in order to be classified as the "same" phonologically. In addition, it is possible to refer to articulatory, acoustic and orthographic evidence (Major, 1994: 186). For example, English and Italian /t/ may be classed as articulatorily similar as each employs articulatory mechanisms associated with plosives (complete closure, pressure build up and release) in adjacent areas of the vocal tract (alveolar and dental respectively). In addition, this articulatory correspondence results in a similar acoustic output, although differences in phonetic cues such as VOT

are evident in acoustic analyses. Finally, both sounds share the same orthographical character <t>. Such similarities may cause these two sounds to be identified with one another despite variations in phonetic cues.

2.2.2 The function of equivalence classification in L1 and L2 acquisition

Flege (1997: 12) describes equivalence classification as a cognitive function which allows humans to perceive categories despite the presence of "inherent sensory variability" amongst constituents of a given category. In terms of L1 acquisition, equivalence classification refers to the grouping together of sounds which differ in articulatory and acoustic output but which share communicative functions in a given language, for example, by belonging to the same phonetic or phonological category (Flege, 1997: 12). On a phonetic level, equivalence classification occurs as a result of the identification of phonetic units, for example, when infants begin to perceive variant sounds as "identical to the prototype" of a language-specific phonetic category (Kuhl, 2004: 835). On a phonemic level, equivalence classification refers to the grouping of phonetic units into phonemes, for instance when native English infants group phonetic units [t] and [t^h] together as realisations of the phoneme /t/ (Flege, 1997: 13).

Previous studies suggest that very young infants do not process speech sounds in this manner, indicating that the ability to categorise sounds in accordance with native speech patterns occurs as a function of language development (Eimas et al., 1971; Lasky et al., 1975; Werker & Lalonde, 1988; Werker & Tees, 2002). Kuhl (2004: 831) proposes that infants are born with the ability to discriminate between the entire set of phonetic contrasts used in the world's languages, that is, that they are sensitive to subtle acoustic differences caused by variations in articulatory and phonatory gestures which constitute phonetic units in all of the world's languages. However, as infants receive increased exposure to the ambient language and L1 acquisition progresses, their initial capacity to distinguish between cross-linguistic phonetic units is succeeded by an enhanced capacity to discriminate phonetic contrasts which are specific to the ambient language. For example in Werker & Tees (2002: 121) English infants of 6-8 months are able to discriminate phonetic contrasts in Hindi that are not employed in English, whereas infants as young as four demonstrate a decline in this ability. This phenomenon is accounted for by the notion that the boundaries which differentiate phonetic units (thus constituting phonetic contrasts) are subject to cross-linguistic variation: as infants are increasingly exposed to L1 they become more sensitive to the boundaries which are specific to their native language.

A decline in the ability to distinguish cross-linguistic variation in exchange for increased sensitivity to language specific contrasts assists in L1 acquisition as it renders communication more efficient: infants develop the ability to process sounds according to language specific categories despite variation amongst speakers, speaking rate and context. It is this mechanism of identifying speech sounds as members of the same category despite acoustic and articulatory variation that Flege (1995: 239) refers to as equivalence classification. It is hypothesised that whilst the mechanism of equivalence classification assists in first language acquisition, it leads to a decline in the acquisition of L2 sounds which have L1 counterparts as it causes individuals to ‘perceptually relate’ (Flege, 1995: 238) L2 sounds with the corresponding L1 sound, despite acoustic and

articulatory variation. Consequently, adults process L2 sounds with the existing corresponding L1 phonetic category, resulting in production of an L2 sound which exhibits influence from L1 and which does not fully realise cross-linguistic variation. This mechanism accounts for the observed age related differences in the acquisition of L2 sounds. It is thought that increased sensitivity to language specific boundaries causes adults to process sounds which vary cross-linguistically with existing L1 categories, thus inhibiting native-like production. In contrast, children with less language specific sensitivity are less likely to identify L2 sounds with existing categories, leaving them more open to introducing these sounds to their existing L1 phonetic system.

This accounts for the compromise values produced by adults for L2 sounds which are similar to L1 sounds but which differ in terms phonetic cues. For example, in Flege (1991) whilst early Spanish-English bilinguals produced /t/ with monolingual values in both languages, indicating that they had established separate categories for both sounds, late Spanish-English bilinguals produced English /t/ with compromise values (mean = 40ms) which were intermediate to English and Spanish monolingual values (mean = 64ms and 22ms respectively). Consequently, the late bilinguals did not reach native-like proficiency, but instead produced /t/ with VOT which was shorter than that of native English speakers, thus exhibiting influence from L1 VOT values. It was hypothesised that equivalence classification between English and Spanish /t/ caused English /t/ to be produced with the existing Spanish category, thus preventing the addition of a new category and inhibiting acquisition of typical English VOT values.

It is important to note that whilst equivalence classification indicates that sounds are "perceptually linked" in terms of belonging to the same category, it is unlikely that it prevents individuals from perceiving cross-linguistic variation in its entirety (MacKay et al., 2001: 516; Best et al., 2001; Werker & Tees, 2005). For example, compromise values observed in SLA indicate that whilst individuals do not attain native-like values, phonetic learning has taken place to some degree. It is that proposed that phonetic learning cannot occur in the absence of perceived differences between L1 and L2 sounds as individuals require "sensory input" from the L2 in order to direct phonetic learning (MacKay et al., 2001: 516). Interaction between perception and production is beyond the scope of this study (see Escudero 2005:306). However, whilst non-native values in adult SLA may be linked to limitations in perception, it seems reasonable to propose that adults must be able to detect *some* of the phonetic differences; otherwise phonetic learning would not be permitted to take place (Flege, 1995: 238; McCandliss et al., 2002).

2.3 Plasticity in the adult L1 phonetic system

2.3.1 Loss of neural plasticity

The capacity of the adult L1 phonetic inventory to be modified (plasticity) in response to L2 exposure bears directly on the degree of phonetic learning ultimately achieved in L2. It is often proposed that adults fail to attain native-like proficiency in L2 due to a loss of plasticity in the language acquisition mechanism in the adult brain (Seliger, 1978: 16; Patowski, 1990). It is thought that during L1 acquisition neural networks in an infant's brain become committed to patterns which mirror input received from the native language. This process is referred to as 'native language neural commitment' (NLNC) (Kuhl, 2004). By hypothesis, NLNC inhibits phonetic learning in adult SLA as it causes a

reduction in the plasticity required to restructure neural networks for the purpose of processing L2 sounds.

There is much disagreement within the linguistic community with regards to how much plasticity remains in an adult's phonetic system, or whether there is in fact any loss at all (Flege, 1987). However, it is generally accepted that the adult brain maintains some degree of plasticity for the acquisition of L2 sounds (McCandliss et al., 2002, Zhang et al., 2009). If this were not the case, once neutral patterns are committed on completion of L1 acquisition we would expect even the most proficient adult second language speakers to produce L2 sounds with pre-existing L1 values, thus exhibiting no phonetic learning whatsoever. A large body of research provides evidence of phonetic learning in L2, for example in the native-like attainment of French /y/ by experienced native English adults (Flege, 1987), or with specific reference to the current investigation, in the compromise values produced in L2 sounds which are subject to equivalence classification (Flege, 1987, 1991; Major, 1994). These studies indicate that whilst adults may not attain native-like proficiency for similar sounds, they are capable of phonetic learning to some degree.

2.3.2 Merged categories

Studies in which adults showcasing phonetic learning in L2 produce corresponding L1 sounds with values which differ from that of L1 monolinguals indicate that the adult L1 phonetic system retains a relatively high level of plasticity for phonetic learning. It is hypotheised that as phonetic learning in L2 progresses, an adult's L1 category evolves in order to 'reflect input' from L2. This creates a 'merged category' which is employed in the production of corresponding L1 and L2 sounds (MacKay et al., 2001: 516). Adjustment to the L1 category in this manner allows individuals with merged categories to approach phonetic norms of the counterpart L2 sound, although generally without attaining native-like values due to its basis in the L1 phonetic system. Accordingly, approximation of the L2 sound results in changes to how the corresponding sound is produced in L1.

The merged category hypothesis is supported by several studies in which adults who have lived in an L2 speaking country for many years produce L1 sounds with values which differ from that of L1 monolinguals in the sense that they appear to have assumed characteristics of the corresponding L2 sound (Flege, 1987; Major, 1994; Sancier & Fowler, 1997; Makay et al., 2001). For example in Major (1994) native speakers of American-English who emigrated to Brazil as adults demonstrated evidence of a merged category for /t/ in English and Portuguese as they produced English /t/ with values which were shorter, and therefore more Portuguese-like than American English norms. As participants also exhibited compromise values in their productions of Portuguese /t/, it was hypothesised that the original category for English /t/ had been modified in the direction of Portuguese /t/ in order to permit production of Portuguese /t/ with VOT values which were more native-like. Studies which provide evidence of merged categories indicate that the L1 phonetic system maintains a considerable amount of plasticity in adulthood as existing categories appear to be restructured for the purpose of approximating corresponding L2 sounds.

2.4 Has the importance of input in phonetic learning been underestimated?

The role of input in SLA remains contentious. Results of studies investigating the length of residence (LOR) in an L2 speaking country which is considered to be an 'index' of input received over the years vary considerably (Tsukada & Roengpitya, 2008: 326). For example, whilst many studies have indicated that (LOR) is of little or no significance in adult phonetic learning (Oyama, 1976; Tahta et al., 1981; Thomson, 1991) a number of studies have shown that phonetic learning increases in line with LOR (Flege & Fletcher, 1992; Flege & Liu, 2001).

Studies investigating phonetic learning independent of LOR across groups of adult learners who do not all reside in an L2 speaking country indicate that phonetic learning increases in accordance with increased input. For example, Flege (1987) compared VOT in productions of French /t/ for native English speakers who varied in terms of the amount of received French input. VOT became progressively more native-like on a scale from least input received to most input received in the following order: students studying French in America who had recently returned from a year in France, American professors of French who were frequently exposed to the speech of native French speakers, and Americans who had been living in France for the past 12 years. Similarly, in Tsukada & Roenpitya (2008) native speakers of Thai residing in their home country were found to perceive instances of English stops /p t k/ more accurately in line with increased English input.

It has been proposed that some studies may show input to be of little or no significance in adult phonetic learning as a result of poor quality input received by participants (Flege & Liu, 2001: 543; Flege, 2009: 117; Gass & Lakshmanan, 1991). Flege (2009: 117) notes that adult immigrants are likely to receive input which may not facilitate phonetic learning as they are more likely to socialise with non-natives who do not provide native-like L2 target models, or compatriots who 'match' and 'reinforce' non-native pronunciation. Consequently, studies which indicate that input is not significantly influential in adult phonetic learning may have investigated individuals who have received low quality input due to various socio-cultural factors, leading to an underestimation of the importance of input in adult SLA (Flege, 2009: 117). In order to avoid possible interference from non-native input, the current study measures input received from native Italian speakers.

3. Motivation for the current study

The current study sets out to investigate three principle areas of interest in native English acquisition of Italian voiceless plosive /t/. Firstly, it aims to identify to what extent late bilinguals exhibit phonetic learning in their production of Italian /t/. Secondly, it seeks to explore the influence of quantity of native speaker input on phonetic learning by comparing Italian realisations of /t/ produced by groups of native English speakers who have received different amounts of input from native Italian speakers. Finally, it aims to identify whether production of English /t/ is modified in line with phonetic learning in Italian /t/, and if so whether this increases in line with increased input received from native Italian speakers. The investigation is divided into three sections:

1) A preparatory experiment aims to identify variation in a selection of phonetic cues in

Italian and English /t/ by investigating phonetic variation between VOT, closure duration and burst amplitude in Italian and English monolingual productions. This is for the purpose of identifying cross-linguistic variation against which to measure phonetic learning: native English speakers would be able to accurately produce phonetic cues which do not show cross-linguistic variation by using existing English values, thus not showcasing phonetic learning.

2) The second experiment investigates the extent to which late bilinguals exhibit phonetic learning in Italian /t/ by making two comparisons. The first is between late bilingual Italian /t/ and monolingual English /t/ in order to identify whether Italian /t/ is produced differently from phonetic norms established in L1, thus exhibiting phonetic learning. If phonetic learning is observed, a second comparison will be carried out between late bilingual Italian /t/ and Italian monolingual /t/ in order to identify whether phonetic learning is complete in the form of native-like Italian values. In addition, it aims to identify if phonetic learning in Italian /t/ has coincided with any modifications to the way in which English /t/ is produced by comparing late bilingual English /t/ against monolingual English values.

3) The third experiment investigates whether phonetic learning increases in line with amount of received input by comparing Italian /t/ produced by the late bilinguals and three groups of native English students who have received varying levels of input from native Italian speakers. These groups are termed low exposure participants (LEP) with reference to the fact that they have received considerably less input from native Italian speakers in comparison to the late bilinguals. In addition, it compares realisations of English /t/ produced by these groups in order to identify whether English /t/ is modified in line with increased levels of received native speaker input, both on a weekly basis and in terms of years of learning in the following order:

LEP beginner < LEP intermediate < LEP advanced < late bilinguals

Least received input Most received input

4. Hypotheses

A series of hypotheses have been formed in light of the research reviewed in section 2.

Hypothesis 1: In line with research examined in section 2.1 which identifies VOT variation in voiceless plosives between Germanic languages such as English and Romance languages such as Italian, it is predicted that VOT will vary significantly in Italian and English monolingual productions of /t/, which will be realised as short-lag and long-lag respectively. In line with Butcher (2004) burst amplitude and closure duration are predicted to show little or no variation. Subsequent hypotheses are based on VOT measurements as phonetic learning can only be measured between cues which show variation. If any difference is found between closure duration and burst amplitude further predictions will be made accordingly.

Hypothesis 2: In line with research reviewed in section 2.3 which states that the adult L1

phonetic system is capable of phonetic learning to some degree, it is predicted that the late bilinguals will exhibit phonetic learning in Italian /t/ in the form of VOT values which are shorter, and thus more Italian like than that of English monolinguals. However, in accordance with the equivalence classification hypothesis outlined in section 2.2, which states that sounds which have an L1 counterpart tend not to be produced with native-like L2 values, it is predicted that late bilinguals will not exhibit full phonetic learning in the form of native Italian values. This will be supported if the late bilinguals produce Italian /t/ with VOT values which are longer, and thus more English-like than that of the Italian monolinguals. Consequently, it is predicted that the late bilinguals will display partial phonetic learning in Italian /t/ in the form of compromise values which are intermediate to Italian and English monolingual values.

Hypothesis 3: Section 2.3.2 reviewed previous research which indicates that late bilinguals produce corresponding L1 and L2 sounds with a merged category, causing modifications to how the L1 sound is produced. It is predicted that late bilingual phonetic learning in Italian /t/ will coincide with modifications to English /t/ which will exhibit influence from Italian VOT values. This hypothesis will be supported if the late bilinguals produce English /t/ with VOT values which are shorter, and thus more Italian-like than that of the English monolinguals.

Hypothesis 4: In line with research examined in section 2.4 which indicates that increased phonetic learning in L2 occurs in line with an increase in quantity of received L2 input, it is predicted that phonetic learning will increase on a scale from least native input received to most native input received for the native English speakers acquiring Italian. This prediction will be supported if VOT values for the four groups decreases on a scale from longest (most English-like) to shortest (most Italian-like) as follows:

LEP beginner > LEP intermediate > LEP advanced > late bilinguals

Hypothesis 5: In accordance with hypothesis 3, it is predicted that phonetic learning in Italian /t/ will coincide with modifications to English /t/. Therefore, it is predicted that VOT in English /t/ will exhibit progressively more influence from Italian /t/ as phonetic learning increases. This hypothesis will be supported if VOT in English /t/ decreases following the scale outlined above.

5. Experiment 1

This experiment aims to investigate hypothesis 1 which states that VOT will show cross-linguistic variation between English and Italian monolinguals of /t/, but that closure duration and burst amplitude will exhibit little or no variation. This hypothesis will be examined by making a direct comparison between these phonetic cues in monolingual Italian and English productions of /t/. The purpose of this investigation is to determine whether these phonetic cues exhibit enough phonetic variation to be used as indicators of phonetic learning. Phonetic cues which exhibit significant variation will be used as points of reference against which to compare values produced by the native English speakers in the process of acquiring Italian.

5.1. Method

5.1.1 Participants

Participants were 9 native English monolinguals and 9 native Italian monolinguals who had lived in their respective native countries since birth. The English participants were recorded in Leeds (UK) and had a mean age of 36 (SD = 12.66). The Italian participants had a similar mean age of 39 (SD = 17.25) and were recorded in Milan and Ferrara (Italy). None of the participants reported having strong regional accents: the Italian monolinguals had lived in the north of Italy for the majority of their lifetimes and did not exhibit salient accent features with regards to VOT whereas the English monolinguals possessed accents which were close to RP. Although some of the monolinguals reported having received education in other languages, none had studied any language at a level higher than GCSE, or the Italian equivalent. None of the Italian subjects reported more than a minimal knowledge of English. In addition, none of the participants reported frequent exposure to any language other than their L1 during their lifetime. Participant characteristics are summarised in Table 1.

Table 1: Italian and English monolingual speaker characteristics. [a] Participant [b] Place of birth

p[a]	age	POB[b] (Italy)	p[a]	Age	POB[b] (UK)
1	55	Sardinia	10	47	Clowne
2	23	Calabria	11	45	Newcastle
3	23	Puglia	12	23	Chesterfield
4	64	Ferrara	13	23	The Wirrel
5	53	Ferrara	14	50	Manchester
6	48	Puglia	15	45	Bradford
7	20	Ferrara	16	46	Lancashire
8	49	Ferrara	17	23	Epsom
9	23	Ferrara	18	22	London

5.1.2 Apparatus and Materials

A Zoom H2 digital recorder was used to record the utterances of the English and Italian monolinguals in wav format, which were of a suitable quality for the intended acoustic measurements. Italian and English words with word-initial /t/ tokens were selected on the basis of phonetic likeness. All words were disyllabic and followed by the vowel /i/ which is of similar quality in both English and Italian (see Appendix 1). Similarly, lexical stress fell on the first syllable for all words in both languages. Some of the English words selected were compound words due to lexical paucity. Words occurred phrase finally in English and Italian carrier phrases which were synonymous and contained the same number of syllables. The English carrier phrase 'I have a _' was followed by target English words: *teacher, teapot, t-shirt, teammate*, *teaspoon* and *teacup*. The corresponding Italian carrier phrase 'io ho un _' was followed by target Italian words: *timbro, tino, tinto, tipo, tiro* and *timo*. For each language the 6 target words appeared twice with the aim of generating a total of 12 /t/ tokens per participant. In order to avoid list intonation additional unrelated phrases were inserted between carrier phrases.

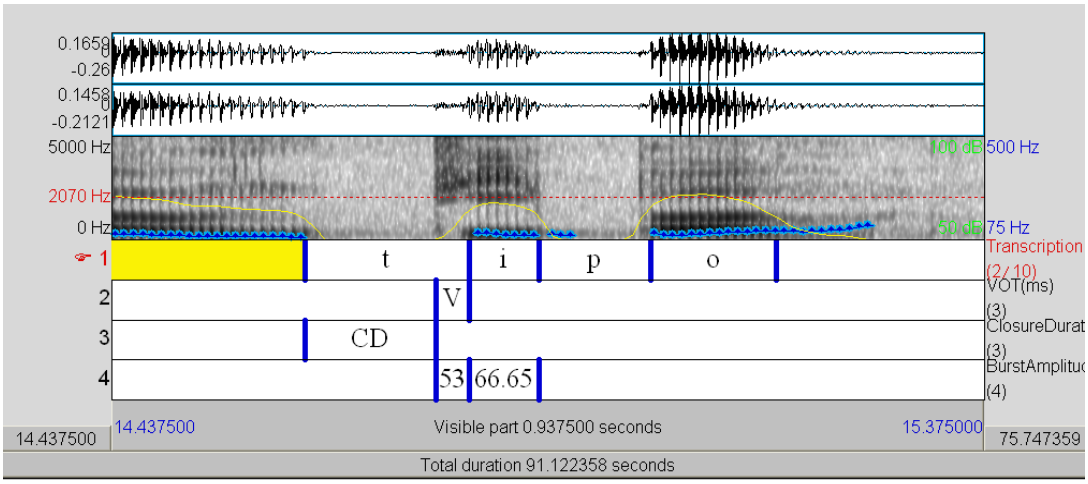
5.1.3 Procedure

Recording took place in the participants' homes. Care was taken in each location to ensure that background noise was minimal. Each group received instructions in their native language. Participants were aware that the experiment examined pronunciation, but were not informed as to which specific aspect would be assessed. Subjects were given the opportunity to read through the set of phrases which were printed on a sheet of paper. Use of more advanced methods such as Powerpoint was impracticable as recording took place in various locations and access to computers was limited. Prior to recording the target phrases, participants were asked to read a number of test phrases in order to become comfortable with the recording process. In order to elicit speech which was as natural as possible, participants were asked to speak as they would with friends and were instructed to read at a normal speed and volume with brief pauses between phrases. Participants spoke their respective languages at their normal speech rate.

5.1.4 Measurements

A total of 216 /t/ tokens were measured: 108 for the Italian monolinguals (12 tokens per person x 9 participants) and 108 for the group of English monolinguals (12 tokens per person x 9 participants). Tokens were recorded in stereo at 16-bit resolution and re-digitised on Praat at a sampling rate of 11.025Hz for analysis (see Figure 2).

Figure 2. Spectrogram indicating sample acoustic measurements for VOT (V), closure duration (CD) and burst amplitude in dB with following vowel amplitude (on bottom row).



Given the importance of the temporal aspect in VOT and closure duration, measurements were taken primarily from the waveform due to poor time definition in the spectrogram. The spectrogram was consulted in parallel with the waveform in order to identify the onset and cessation of vocal fold vibration for VOT and hold phase measurements respectively. VOT measurements were taken on the waveform from the beginning of the aperiodic energy signaling the release burst to the first peak of the sudden appearance of periodic vibration which corresponds to the onset of the following vowel. Closure duration was identified as the period between closure onset and consonant

release. Closure onset was measured from the peak of the final wave on the waveform where the amplitude is almost zero after the termination of vocal fold striations on the spectrogram. Closure release was measured as the peak of the sudden burst of energy in the waveform, with reference to the abrupt appearance of dark acoustic energy in the spectrogram. Burst amplitude was taken using relative amplitude measurements which consisted of measuring the difference between the area of highest energy in the middle of the release burst and the area of highest energy in the middle of the following vowel. The dB values for the vowel were then subtracted from that of the release burst, providing a negative value. Mean VOT, closure duration and burst amplitude values were calculated for each participant. Statistical analysis was performed on mean values using SPSS.

5.2 Results

Table 2. Mean values and standard deviations for Italian and English monolingual productions of /t/.

	VOT in ms (SD)	Closure Duration in ms (SD)	Relative Burst Amplitude In dB (SD)
Italian monolinguals	32.62 (8.54)	94.79 (23.38)	-11.50 (1.88)
English monolinguals	80.95 (7.89)	80.75 (23.25)	- 11.60 (3.55)

5.2.1 Voice-onset time

VOT values in Italian and English monolingual realisations of /t/ are presented in Table 2 and Figure 3. Italian VOT (mean = 32.62ms SD = 8.54) was considerably shorter than English VOT (mean = 80.95ms, SD = 7.89). Mean values indicate that Italian and English /t/ were realised as short-lag and long-lag respectively. VOT in Italian /t/ occurred towards the higher end of the durational constraints identified for short lag stops of around 20-35ms (Keating 1984). English /t/ tokens were considerably longer than the minimum long-lag duration of 35ms, with values which are consistent with a number of previous studies (Flege 1987; Major 1994) An independent *t*-test revealed the difference between English and Italian VOT to be significant [$t(16) = -12.48$, $p < .001$ (one-tailed)] with a substantive effect size of $r = .95$.

5.2.2 Closure Duration

Closure duration values are shown in Table 2 and Figure 4. Italian monolingual values (mean = 94.79ms, SD = 23.38) were longer than that of the English monolinguals (mean = 80.75 ms, SD = 23.25). However, this difference was non-significant [$t(16) = 1.28$, $p > .05$ (one-tailed)].

Figure 3. VOT in monolingual realisations of /t/.

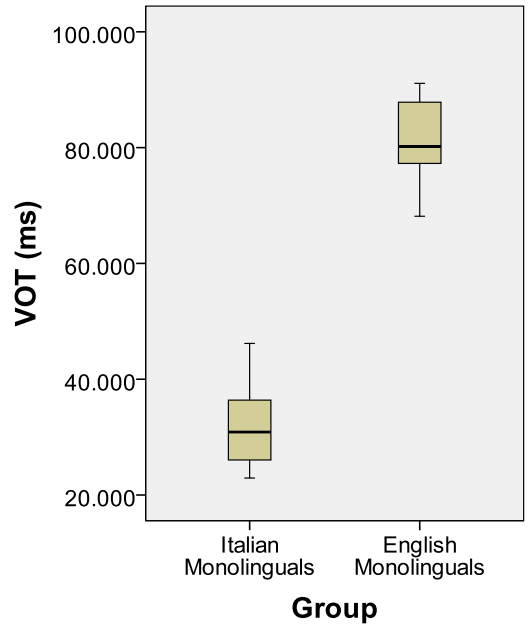
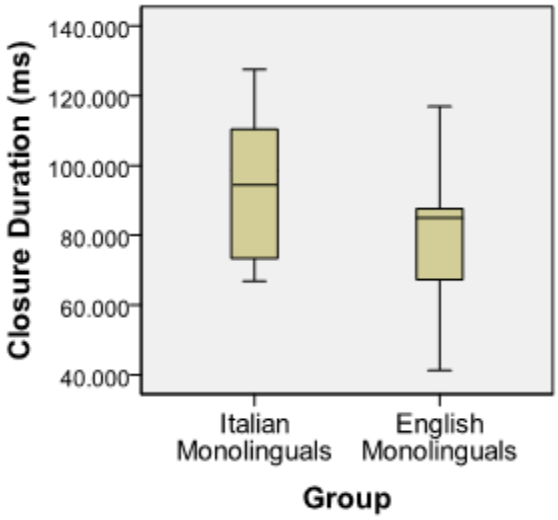


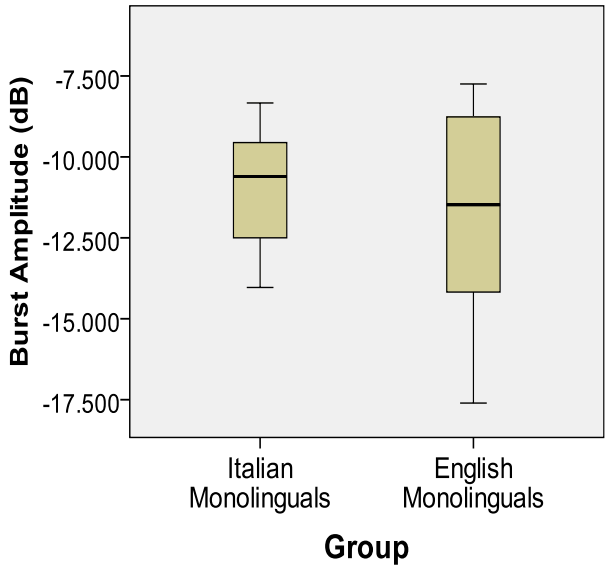
Figure 4. Closure duration in monolingual realisations of /t/.



5.2.3 Burst Amplitude

Table 2 and Figure 5 show monolingual relative burst amplitude values. Mean relative burst amplitude for the English and Italian monolinguals occurred within one dB of each other at -11.60 dB and -11.50 dB respectively. Italian monolingual burst amplitude was slightly higher than that of the English monolinguals, however this difference was non-significant [$t(16) = .380$, $p>.05$(one-tailed)].

Figure 5. Burst amplitude in monolingual realisations of /t/



5.3 Discussion

This experiment aimed to identify cross-linguistic variation in some of the phonetic cues which constitute the voiceless stop consonant /t/ in English and Italian. VOT in Italian monolingual /t/ was significantly shorter than that of English monolingual /t/. Italian and English VOT values were realised as short-lag and long-lag respectively. Closure duration and burst amplitude did not differ significantly. These results offer support for hypothesis 1, as only VOT was found to vary significantly between monolingual Italian and English /t/. The current study will not investigate closure duration and burst amplitude further as they have not exhibited significant cross-linguistic phonetic variation and thus do not serve as an effective measure of phonetic learning for native English speakers acquiring Italian. In contrast, significant differences in VOT indicate that it is an ideal phonetic cue against which to measure phonetic learning.

6. Experiment 2: The extent of phonetic learning in late bilingual productions of /t/.

The first part of this experiment aims to examine hypothesis 2, which predicts that the late bilinguals will demonstrate partial phonetic learning, producing Italian /t/ with compromise VOT values. This will be investigated by making two comparisons. The first will be between English monolingual /t/ and late bilingual realisations of Italian /t/ in order to identify whether the late bilinguals are able to produce Italian /t/ with values which are shorter than that of the English monolinguals, thus exhibiting phonetic learning by producing a sound with values which differ from that of the their L1 phonetic system. This method is frequently used in order to test for phonetic learning as an intrasubject comparison of late bilingual L2 productions against their L1 productions may be inappropriate due to a possible shift in the L1 category (Flege, 1991; MacKay et al., 2001). However, monolinguals have been observed to produce sounds which differ from their native languages by implementing techniques which are unrelated to phonetic

learning such as imitation (Flege & Hammond, 1982). Consequently, it is possible that native English individuals are capable of producing VOT values which differ from that of L1 without having achieved phonetic learning. A preparatory comparison will be undertaken between English monolingual values and realisations of Italian /t/ produced by the LEP beginner group which is assumed to have achieved very little or no phonetic learning in Italian. If VOT in beginner realisations of Italian /t/ are not significantly different from English monolingual realisations of /t/, it will indicate that adults do not produce Italian /t/ differently to English /t/ without having undergone the gradual process of phonetic learning. In this eventuality, a comparison between late bilingual production of Italian /t/ and English monolingual /t/ will be deemed an effective measure of phonetic learning.

If phonetic learning is observed to have taken place, a second comparison will be made between late bilingual Italian realisations of /t/ and monolingual Italian realisations of /t/ to identify whether late bilingual VOT values are in line with that of Italian monolinguals, indicating complete phonetic learning. Phonetic learning which is incomplete will be deemed as partial phonetic learning (compromise values).

The second part of this experiment examines hypothesis 3, which states that phonetic learning in Italian will be accompanied by modifications to VOT in English /t/. This will be investigated by making a direct comparison between VOT in late bilingual and English monolingual productions of English /t/.

6.1 Method

6.1.1 Participants

A group of 9 English-Italian bilinguals who emigrated to Italy as adults (mean age = 48, SD = 8.63) were recorded in Milan, Italy. Participants were taken from the British Consulate and the British Council. In line with previous studies, the participants were classed as late bilinguals in that they were first exposed to L2 after the age of 15, and had been living in the L2 speaking country for a minimum of 15 years (mean = 25 years, SD = 7.48) (Flege et al., 2001: 519; Flege, 1991: 397). Whilst it was not possible to obtain participants who had never learned any languages other than Italian, none of the subjects used languages other than English and Italian on a daily basis. In addition, 7 LEP beginners who had been learning Italian in English classes for less than 1 year and received 4 or less hours exposure to the speech of native Italians per week were included in a preparatory experiment. Monolingual participants from experiment 1 were included in order to compare productions against Italian and English phonetic norms. Participant characteristics are summarised in Table 3.

Table 3. Late bilingual and LEP beginner characteristics. [a] Participant [b] length of residence [C] age of learning (age of first exposure to Italian) [d] weekly exposure to native Italian speech.

	P[a]	Age	LOR[b]	AOL[c]	Exp NI[d]
Late bilinguals	19	64	37	18	30-40
	20	49	27	22	80
	21	50	18	18	60
	22	40	19	21	80
	23	53	30	23	60
	24	46	20	22	40
	25	47	29	18	60
	26	52	18	16	120
	27	33	15	18	115
LEP Beginners	28	44	0	44	4
	29	21	0	21	3
	30	24	0	24	3
	31	42	0	42	3
	32	37	0	37	3
	33	21	0	21	3
	34	23	0	32	3

6.1.2 Apparatus, Materials and Procedure

Apparatus and materials were identical to those used in experiment 1. Recording took place in a meeting room at the British Consulate and in classrooms at the British Council. Procedures were carried out as in experiment 1, except that the late bilinguals were required to read both English and Italian phrase sets.

6.1.3 Measurements

A total of 384 /t/ tokens were measured: 192 realisations in Italian (12 tokens per person x 16 participants) and 192 realisations in English (12 tokens per person x 16 participants). Measurements were carried out using the methods outlined in experiment 1. Monolingual tokens measured in experiment 1 were included in the analysis.

6.2 Results

6.2.1 Italian /t/

An independent *t*-test was undertaken to determine whether VOT in Italian /t/ produced by the LEP beginner group differed from that of monolingual English values. LEP beginner VOT (mean = 77.24, SD = 3.9) was not significantly different from that of the English monolinguals (Mean = 80.95, SD = 7.89 [$t(14) = .759$ $p > 0.5$] (Table 4). This indicates that native English speakers who have undergone very little or no phonetic learning did not produce Italian /t/ with values which differ from that of English /t/ under the conditions of the current study. As a result, a comparison of late bilingual realisations of English /t/ against English monolingual values is deemed to be an effective measure of phonetic learning.

Table 4. Mean VOT in ms and standard deviations for English monolinguals and LEP beginners

	Italian VOT (SD)	English VOT (SD)
Monolingual English	--	80.95 (7.89)
LEP Beginners	77.24 (3.9)	--

A series of independent *t*-tests were carried out to identify whether phonetic learning occurred for the late bilinguals and if so, whether it was partial or complete. The first *t*-test compared late bilingual Italian /t/ with monolingual English /t/. Table 5 and Figure 6 show VOT values for monolingual English and late bilingual Italian realisations of /t/. VOT values for late bilingual Italian /t/ (mean = 59.98 ms, SD = 19.82) were significantly shorter than those of the English monolinguals (mean = 80.95 ms, SD =7.89) [$t(3) = 10.5$, $p < .01$ (one-tailed)] This was accompanied by a substantive effect size of $r = .97$.

Table 5. Mean VOT in ms and standard deviations for English and Italian monolinguals and late bilinguals

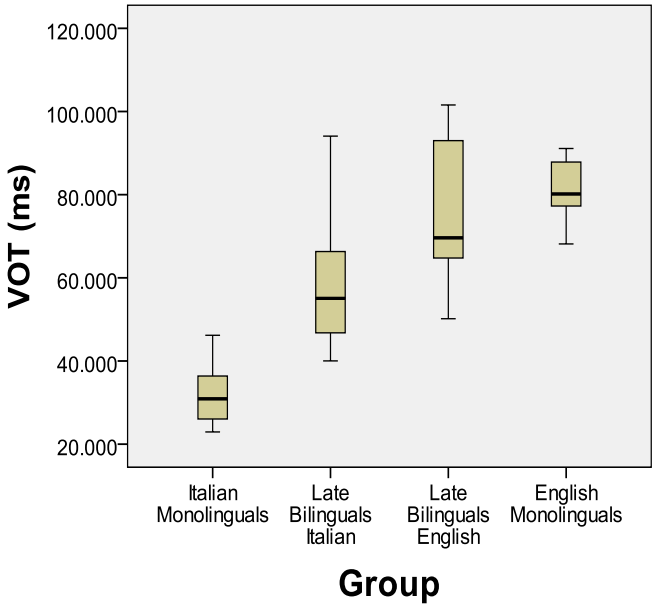
	Italian VOT (SD)	English VOT (SD)
Monolingual Italian	32.62 (8.54)	--
Late Bilingual	59.98 (19.82)	76.31 (17.08)
Monolingual English	--	80.95 (7.89)

A second *t*-test compared late bilingual realisations of Italian /t/ against monolingual Italian /t/. Table 5 and Figure 6 show VOT values for these productions. Late bilingual Italian /t/ (mean 59.98 ms SD = 19.82) was significantly longer than that of the Italian monolinguals (mean = 32.62 ms SD = 8.54) [$t(10.87) = -3.804$, $p < .005$ (one-tailed)] with a large effect size of r =.57.

6.2.2 English /t/

The third *t*-test compared English monolingual and late bilingual realisations of English /t/. Table 5 and Figure 6 show VOT for English monolingual and late bilingual productions of English /t/. VOT in late bilingual productions of /t/ (Mean = 76.31 ms, SD = 17.08) was found to be slightly shorter than that of monolingual production of English /t/ (Mean = 80.95 ms, SD = 7.89). However, this difference was non-significant [$t(11.27) = .739$, $p > .05$ (one-tailed)].

Figure 6. VOT in monolingual and late bilingual productions of Italian and English /t/



6.3 Discussion

This experiment aimed to address to what extent late English-Italian bilinguals exhibit phonetic learning in Italian /t/. Late bilinguals produced Italian /t/ with significantly shorter VOT than that of the English monolinguals which indicates that phonetic learning has taken place to some extent. Significant differences between late bilingual Italian /t/ and monolingual Italian /t/ revealed that this phonetic learning was incomplete as the late bilinguals did not produce Italian /t/ with Italian monolingual values. These results support hypothesis 2 as they indicate that the late bilinguals evidenced partial phonetic learning in Italian /t/ but that they did not attain native-like proficiency, resulting in compromise values intermediate to English and Italian phonetic norms. This is consistent with previous studies in which late bilinguals exhibit compromise values in the production of L2 sounds which correspond to existing L1 sounds (Flege, 1987, 1991; Major, 1994).

In contrast to predictions, late bilingual realisations of English /t/ did not differ significantly from monolingual English values. This indicates that the late bilinguals' phonetic category for English /t/ had remained similar to that of English monolinguals and that it had not been restructured over the years as a result of phonetic learning in Italian /t/. This result is in contrast to previous research which indicates that late bilinguals who show signs of phonetic learning in L2 tend to exhibit modifications to the way in which corresponding L1 sounds are produced (Major, 1994). Flege (1991: 409) accounts for phonetic learning which occurs without modifications to the corresponding L1 category by asserting that adults have the capacity to produce L2 sounds differently to current L1 sounds through the addition of realisation rules. It is hypothesised that realisation rules are used in L1 to permit monolingual speakers to produce phonetic variations of an existing L1 phonetic category. This allows individuals to modify their speech for various purposes, for example in order to achieve positive or negative prestige in different social contexts (Labov, 1981). Consequently, speakers who show phonetic

learning in L2 without modifications to the existing L1 category do so by adding new realisation rules to their current L1 category. Flege (1991: 409) maintains that this is a form of phonetic learning in as much as adult speakers of a second language appear to have the capacity to acquire a phonetic realisation rule that monolinguals do not possess. As a result, the late bilinguals in the current study may have achieved phonetic learning in their Italian realisations of /t/ through the addition of new realisation rules which allow them to produce Italian /t/ with shorter VOT than that of typical English monolingual values.

There was a substantial amount of intersubject variability amongst the late bilinguals, as can be seen from the spread distribution in the upper and lower interquartile ranges and the differences between minimum and maximum values displayed by the whiskers in Figure 6. For example, participant 19 who displayed the most phonetic learning in Italian /t/ produced English VOT with values of 50.16ms which were significantly shorter than that of the English monolinguals [$t(8) = 3.70$, $p < .01$] (Table 6). This could indicate that the category for English /t/ has been restructured for this participant. However, this result must be interpreted with caution as these values may simply reflect a natural tendency to produce stops with short VOT values. In contrast, some of the bilinguals appear to have undergone no phonetic learning as they did not produce /t/ with values which were different to English monolinguals. For example participants 21 and 23 produced Italian /t/ with values which were slightly longer than their productions of English /t/ (Table 6). The basis of these individual differences is unclear and may be due to personal differences such as phonetic learning aptitude or motivational factors. The difference does not appear to be related to quantity of native speaker input as subjects 21 and 23 did not report lower received input in terms of LOR or weekly exposure than the other subjects (Table 3).

Table 6. Mean VOT (ms) in late bilingual Italian and English realisations of /t/ indicating intersubject variation.

Participant	Italian VOT	English VOT
19	40.02	50.16
20	55.10	67.81
21	66.33	64.77
22	88.50	92.99
23	94.08	93.18
24	46.89	101.57
25	46.77	69.88
26	41.05	63.88
27	61.11	82.86

7. Experiment 3: Quantity of native speaker input and phonetic learning

The purpose of this experiment is to examine hypotheses 4 and 5 which predict that phonetic learning in Italian VOT and modifications to English VOT will increase in line with increased received native speaker input. However, in light of experiment 2, in which the late bilinguals did not exhibit modifications to English /t/, it seems unlikely that any

of the groups who have received less input will vary in their productions of English /t/.

7.1 Method

7.1.1 Participants

Native English students from the University of Leeds and the University of Manchester participated. All participants had begun learning Italian after the age of 15, except for one who had begun at the age of 14. Participants received input from native Italian speakers in lessons, with language partners or Italian friends and through authentic Italian listening materials such as film and radio. 7 LEP beginners had been learning Italian for less than 1 year and received less than 4 hours exposure to native Italian speech per week. 6 LEP intermediate participants had been learning Italian for 3-4 years and were exposed to the speech of native Italians for 2-4 hours per week. 7 LEP advanced participants had been learning Italian for more than 7 years and were exposed to native Italian speech for at least 9 hours per week. Each member of the LEP advanced group had spent the previous year in Italy and reported minimal or no knowledge of other languages. LEP participant characteristics are summarised in Table 7. The late bilinguals were included as the group who had received the most native speaker input. There was a significant Pearson's correlation between groups in terms of how many years they had been learning Italian, and estimated weekly exposure to native Italian speakers (r = .743 p < .001). For mean quantity of input for the LEP groups in terms of years of learning and weekly exposure, see Table 8.

Table 7. LEP characteristics. [a] Participant [b] length of residence [c] age of learning (age of first exposure) [d] weekly exposure to native Italian speech.

	P[a]	Age	LOR[b]	AOL[c]	Exp NI
Beginner	28	44	0	44	4
	29	21	0	21	3
	30	24	0	24	3
	31	42	0	42	3
	32	37	0	37	3
	33	21	0	21	3
Intermediate	34	23	0	23	3
	35	19	0	16	2
	36	19	0	15	3
	37	18	0	15	4
	38	22	0	18	4
	39	20	0	16	4
	40	20	0	16	4
Advanced	41	22	1	14	20
	42	22	1	15	20
	43	22	1	15	10
	44	23	1	15	12
	45	22	1	15	10
	46	22	1	15	9
	47	25	1	17	14

Table 8. Mean years of learning and weekly exposure (hrs) to native Italian speech.

	Years of learning (SD)	Weekly exposure (SD)
Late Bilinguals	24 (7.48)	77 (31.25)
LEP Advanced	7 (.54)	13 (4.7)
LEP Intermediate	3 (.55)	4 (.37)
LEP Beginner	<1 -	3 (.38)

7.1.2 Apparatus, Materials and Procedure

Apparatus, materials and procedure were the same as those used in experiment 2. Recording took place in classrooms at the University of Leeds and the University of Manchester.

7.1.3 Measurements

A total of 480 /t/ tokens were measured for the LEP groups: 240 realisations in Italian (12 tokens per person x 20 participants) and 240 realisations in English (12 tokens per person x 20 participants). Measurements were carried out using the methods outlined in experiment 1. Tokens measured for the late bilinguals in experiment 2 were also included in the analysis.

7.2 Results

7.2.1 Italian /t/

VOT for the late bilinguals and LEP groups are presented alongside that of Italian monolinguals in Table 9 and Figure 7. Mean VOT for the groups decreased in the following order:

LEP beginner (Mean = 77.24 ms, SD = 17.77) > LEP intermediate (Mean = 63.60 ms, SD = 11.98) > late bilinguals (Mean 59.98 ms, SD 19.82) > LEP advanced (Mean = 42.89ms, SD = 3.82)

Table 9. Mean VOT in ms and standard deviations in Italian /t/ produced by Italian monolinguals, late bilinguals and LEP groups.

	Italian VOT
Italian monolinguals	32.62 (8.54)
Late bilinguals	59.98 (19.82)
LEP Advanced	42.89 (3.82)
LEP Intermediate	63.60 (11.98)
LEP Beginners	77.24 (17.77)

A one way independent ANOVA indicated that there was a significant main effect of native speaker input [$F(3, 25) = 6.10$, $p<.005$] with a strong effect size of $r = .64$. A planned contrast between the late bilinguals and the LEP groups combined revealed that the late bilinguals did not produce significantly shorter VOT values than the LEP groups combined [t (25) = .190 $p > .1$ (one-tailed)]. Amongst the LEP groups, further planned contrasts revealed that VOT for the LEP advanced group was significantly shorter than

that of that of the LEP beginner and intermediate groups combined [$t(25) = 6.25$, $p < .001$ (one-tailed)] with a substantive effect size of $r = 8.0$. Intermediate LEP values were not significantly shorter than beginner LEP values [$t(25) = 1.64$, $p > .05$ (one-tailed)] however, this result approached significance [$p = .061$] and was found to have a medium effect size of $r = .40$.

As mean VOT for the LEP advanced group was shorter and thus more native-like than that of the late bilinguals, a supplementary turkey's test was carried out to see if this difference was significant. The difference was found to approach significance at $p = .068$ (one-tailed).

7.2.2 English /t/

VOT in late bilingual and LEP productions of English /t/ is presented alongside that of the English monolinguals in Table 10 and Figure 8. A non-parametric Kruskal-Wallis one way ANOVA revealed that there was no significant main effect of native speaker input on VOT in LEP and late bilingual productions of English /t/ [x^2 (4) 6.86, $p > .1$]

Figure 7. VOT in Italian /t/ for Italian monolinguals, late bilinguals and LEP groups

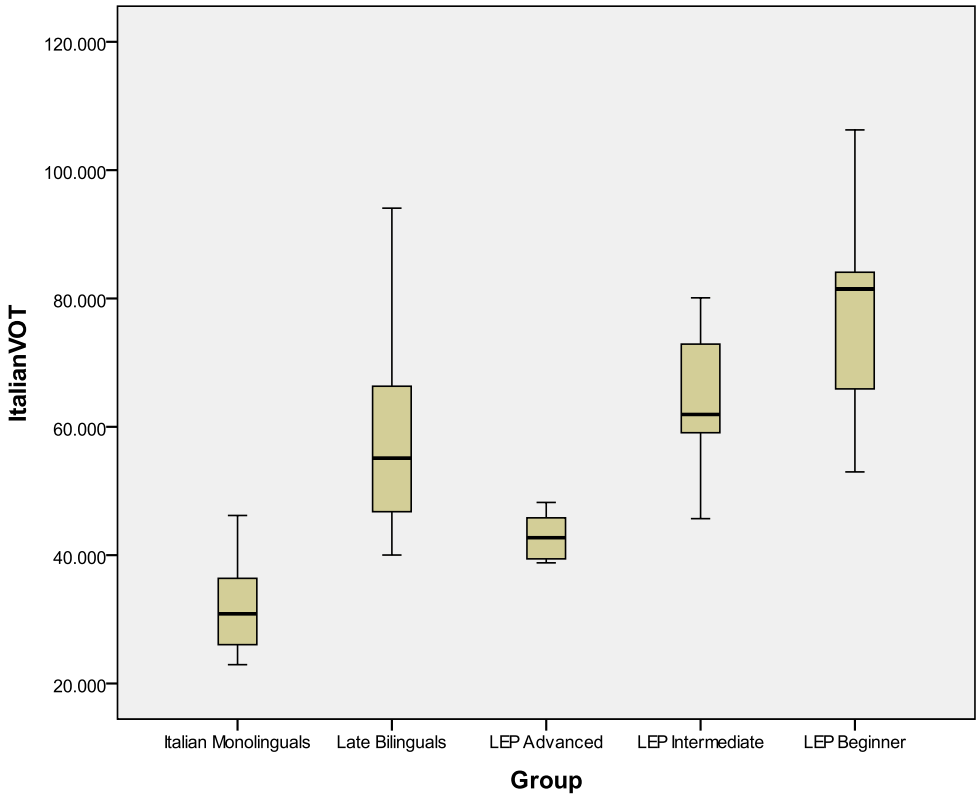


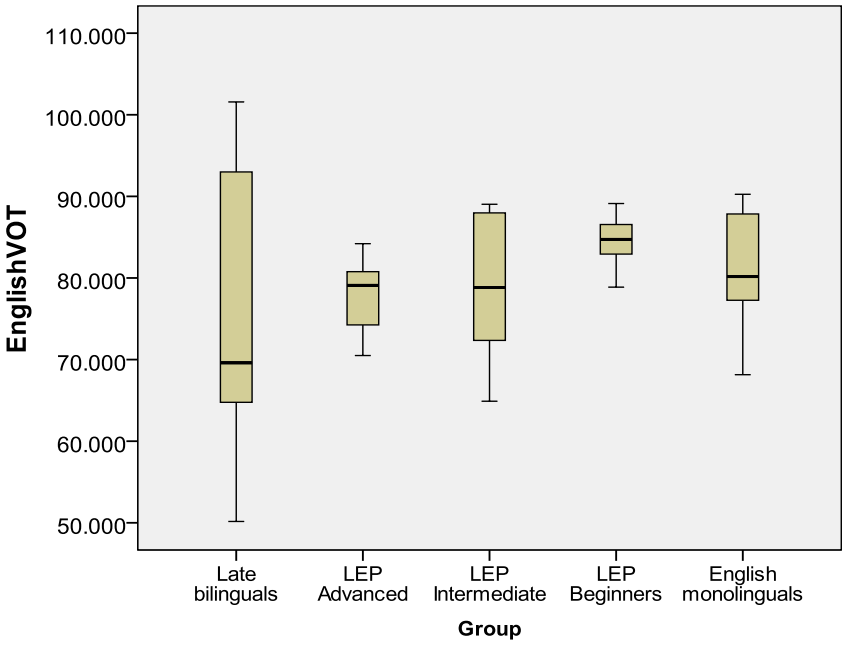
Table 10. Mean VOT in ms and standard deviations in English /t/ produced by English monolinguals, late bilinguals and the LEP groups

	English VOT (SD)
English monolinguals	80.95(7.89)
Late bilinguals	76.31 (17.08)
LEP Advanced	77.69 (5.05)
LEP Intermediate	78.65 (9.86)
LEP Beginners	84.52 (3.45)

7.3 Discussion

This experiment aimed to identify whether phonetic learning increases in line with increased input received from native Italian speakers. Results appear somewhat contradictory. A comparison between the late bilinguals and the LEP groups combined indicates that VOT in late bilingual production of Italian /t/ is not significantly shorter than that of the LEP groups. Given that the LEP advanced group produced Italian /t/ with VOT values which were shorter than that of the late bilinguals (approaching significance, as shown by the supplementary Turkey's test), it seems likely that the LEP advanced VOT values lowered the mean of the LEP groups combined in the first planned comparison. These results indicate that the late bilinguals had not achieved more phonetic learning than the advanced LEP group despite having received a substantially higher quantity of input from native Italian speakers. This is in some contrast to hypothesis 4 as

Figure 8. VOT in English /t/ for English monolinguals, late bilinguals and LEP groups



phonetic learning did not increase in order of least received native speaker input to most received native speaker input. These results support research reviewed in section 2.4 that indicate that input is not a primary predictor of phonetic learning (Oyama, 1976; Tahta et al., 1981; Thomson, 1991). However, amongst the LEP groups input does appear to have influenced production of Italian /t/, with the LEP advanced group producing significantly shorter VOT than the intermediate and beginner groups combined, and the LEP intermediate group exhibiting shorter VOT than that of the LEP beginner group with values which approached significance. These results support hypothesis 4 as phonetic learning appears to have increased progressively as levels of input increased. This is in line with previous research which indicates that input is an important predictor of phonetic learning (Tsukada & Roengpitya, 2008; Flege, 1987; Flege & Liu, 2001). In contrast to hypothesis 5, VOT in English /t/ did not vary significantly between any of the groups. This indicates that phonetic learning in Italian /t/ was not reflected in modifications to the L1 phonetic system.

The following section evaluates some of the possible explanations for the inconsistency of the results which indicate that native speaker input was not an accurate predictor of phonetic learning for the late bilinguals in comparison to the LEP advanced group, but that input was an accurate predictor of phonetic learning between the LEP groups.

7.3.1. Personal factors: motivation, personality and aptitude

Several studies indicate that motivation and personal factors, such as a desire to integrate into the L2 speaking culture and lack of inhibition promote phonetic learning (Gardner & Lambert, 1959, 1972; Guiora et al., 1972). A review of previous research reveals conflicting views on motivational factors. It is possible that the late bilinguals desired to maintain links with their native country, or to identify with the English speaking socio-professional environment which may have caused them to have less motivation to reach native-like proficiency (Flege, 1987). On the other hand, as residents of the L2 speaking country, the late bilinguals might be expected to have a strong desire to integrate into the Italian speaking community, which has been shown to facilitate phonetic learning (Gardner & Lambert, 1972). Similarly, differences in cognitive ability and language aptitude have been shown to cause variation in phonetic learning (Caroll, 1965). The current study did not investigate any of these factors and as a result is unable to comment on their effect on phonetic learning. All of these factors are likely to vary from individual to individual. One of the limitations of this study was that it dealt with small sample sizes. As a result, individual variation such as that of the late bilinguals in experiment 2 is likely to change the means of the group substantially, producing results which may not be an accurate representation of the population of late English-Italian bilinguals. Consequently, a larger sample size may have yielded different results.

7.3.2. Fossilisation

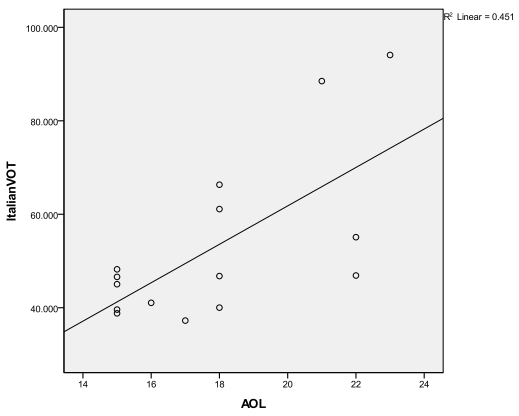
Fossilisation refers to a process in which adult SLA comes to an end before an individual has attained native-like proficiency (Selinker, 1972). Adults acquiring a second language are thought to reach a point in which phonetic learning does not

continue moving towards native-like values and pronunciation becomes "fossilised", regardless of the amount of native speaker input received (Long, 2003; Han. 2004: 213). This could account for why the LEP groups exhibited phonetic learning which increased in line with increased native speaker input whereas the late bilinguals did not exhibit any more than the advanced LEP group. It is possible that native speaker input is influential in the early stages of learning, for example during the stages which correspond to that of the LEP groups, but that after a certain point phonetic learning ceases. Consequently input may have influenced late bilingual phonetic learning in the early stages of acquisition, but after a certain point phonetic learning may have fossilised, leaving them unable to progress regardless of the amount of native speaker input received.

7.3.3. Age of learning

Findings indicated that LEP advanced VOT was shorter than that of the late bilinguals, with values which approached significance. Supplementary Pearson's tests were carried out in order to see whether phonetic learning correlated with age of learning (AOL). As shown in Figure 9, a correlation was found between the age in which Italian acquisition began and the length of VOT in realisations of Italian /t/, with a link between low AOL and shorter, more native-like VOT values (r = .54 p <.05). On the basis of these results it seems reasonable to infer that the advanced LEP group may exhibit more phonetic learning as they began Italian acquisition at a younger age (Mean = 15, SD = .90) than that of the late bilinguals (Mean = 19, SD = 2.5). In line with the fossilisation theory reviewed in the previous section, it is possible that AOL influenced how far phonetic learning was permitted to continue before fossilisation occurred: the late bilinguals have a higher AOL which may have caused phonetic learning to cease further away from native values in comparison to that of the LEP advanced group. The current study is unable to comment on whether advanced learners will continue in their phonetic learning, or whether phonetic learning will fossilise and they will continue to produce Italian /t/ close to present values. Nonetheless, the correlation between AOL and phonetic learning found in this study is consistent with previous studies which indicate that AOL is the strongest predictor of L2 "end state performance", namely, how far phonetic learning in an L2 sound is permitted to progress before fossilisation sets in. Moreover, it is in line with previous studies which indicate that the capacity to approximate native-like proficiency declines gradually as age increases throughout adolescence and adulthood (Yeni-Komshian et al., 1997; Bialystock & Hakuta, 1999).

Figure 9. Correlation between AOL and VOT in late bilingual and LEP advanced productions of Italian /t/.



8. General discussion

The current study aimed to identify to what extent phonetic learning takes place in late English-Italian bilingual productions of Italian /t/, and whether quantity of native Italian speaker input influences phonetic learning in Italian /t/ produced by native English speakers acquiring Italian. In addition, it aimed to identify whether phonetic learning in Italian /t/ coincides with modifications to English /t/. Experiments focused on the acquisition of VOT as it was the only phonetic cue to exhibit variation between English and Italian monolingual productions out of VOT, burst amplitude and closure duration.

The findings of this study are consistent with previous research which indicates that late bilinguals tend not to acquire native-like VOT in L2 sounds which share acoustic, articulatory and phonological features with an existing L1 sound. The late bilinguals failed to reach native-like proficiency as they produced Italian /t/ with VOT which was longer than that of native Italian monolinguals. Longer VOT values indicate influence from English VOT norms which are typically longer than that of Italian. Consequently, in line with the equivalence classification hypothesis, it seems reasonable to infer that these individuals employed their existing category for English /t/ in the production of Italian /t/ due to acoustic, articulatory and phonological similarities. It is proposed that equivalence classification between English and Italian /t/ prevented the addition of a new category for Italian /t/, thus inhibiting native-like proficiency in the production of Italian VOT.

The partial phonetic learning exhibited by the late bilinguals is consistent with previous research in which adults produce L2 sounds which are subject to equivalence classification with compromise values which are intermediate to L1 and L2 phonetic norms. These results indicate that the adult L1 phonetic system is capable of phonetic learning in L2, at least to some degree. However, findings were not in line with previous research which has provided evidence of "merged categories" in which phonetic learning in L2 is thought to result in modifications to how the corresponding L1 sound is produced. The participants in the current study did not exhibit changes to VOT in English /t/, regardless of how much phonetic learning they evidenced in Italian /t/. Consequently, results suggest that whilst the L1 phonetic system exhibits some degree of plasticity as it permits L2 phonetic learning in the form of compromise values, it remains somewhat "committed" (Kuhl, 2004) to the phonetic contrasts acquired in L1 as it is not restructured to the point in which L1 values change. These results must be interpreted with caution as previous research indicates that L1 modification is more salient in casual speech (Major 1994). Consequently, the formal recording conditions in the current study may have prevented the detection of changes to the way in which L1 is produced which might have been present in less formal conditions. A further limitation of this study was that all of the participants received a substantial amount of L1 input during their daily lives, which may have caused them to retain native English values. The late bilinguals taught English at the British council, or had British colleagues at the British consulate, and the LEP groups were residing in the UK at the time of the study. Had participants been living in conditions of complete Italian immersion, modifications to English /t/ may have been observed.

Results for the influence of quantity of native speaker input on phonetic learning in Italian /t/ are in line with the notion that the adult L1 phonetic system remains somewhat committed to the phonetic contrasts acquired in L1. Input appears to have positively

influenced phonetic learning for the LEP groups, but not between the LEP advanced group and the late bilinguals. As only native speaker input was measured, results which suggest that the late bilinguals had not undergone more phonetic learning than the LEP advanced group are in contrast to Flege (2009) who suggests that the importance of native speaker input has been underestimated in adult phonetic learning due to an increased likelihood for adults to receive non-native input. Findings indicate that input is influential in the early stages of SLA but not in the later stages. This supports the notion of fossilisation which states that adults acquiring a second language eventually reach a point in which phonetic learning plateaus and the production of L2 sounds continue to exhibit the same degree of influence from phonetic contrasts acquired in L1 regardless of the quantity of input received. With reference to the present study, this appears to have occurred in late bilingual production of Italian /t/, which was produced with longer VOT values than LEP advanced productions, showcasing a higher degree of influence from English VOT values despite having received more input from native Italian speakers.

One aspect that this study did not set out to investigate, but that is none the less worthy of note is the correlation between AOL and phonetic learning between the most experienced participants. This correlation indicates that AOL is influential in the amount of phonetic learning which is ultimately attained in the later stages of L2 acquisition, as a lower AOL was found to correspond to a higher degree of phonetic learning.

There are some confounding factors which may have influenced this result. The groups may have differed in terms of motivational factors which were not measured. In addition, group size was only small, and may not necessarily be representative of the population of adults acquiring a second language. A longitudinal study which measures VOT as adults progress through the SLA process would be a more ideal experiment design as it would be able to examine the progression of phonetic learning for each individual. This would eliminate the possibility of individual differences causing variation in phonetic learning and would provide a more accurate picture of how phonetic learning progresses in line with increased native speaker input over the years. Unfortunately, this method was unavailable given the time restraints of the current study.

In conclusion, the findings of this study indicate that late English-Italian bilinguals exhibit partial phonetic learning in their productions of Italian /t/. Native-like proficiency was not observed even after many years of residence in Italy. Failure to reach Italian phonetic norms may be attributed to the production of Italian /t/ with the existing category for English /t/ due to articulatory, acoustic and phonological similarities. It is proposed that the acquisition of similar L2 sounds is subject to fossilisation, as quantity of native speaker input appeared to influence phonetic learning for participants who were in the early stages of Italian acquisition, but not for the more experienced participants. Findings provide support for the notion that AOL is an important predictor of how far phonetic learning progresses before fossilisation occurs, with a lower AOL being linked to increased phonetic learning. Finally, the influence of L2 phonetic learning on corresponding L1 sounds remains unclear. Findings in the current study suggest that the L1 system is not capable of being restructured to the point in which L1 pronunciation changes as a result of phonetic learning in L2. These findings are consistent with the fossilisation hypothesis, as they indicate that there is a degree of inflexibility in the adult L1 phonetic system. However, further research on native English speakers acquiring

Italian in conditions of complete immersion would be necessary to corroborate these findings.

[1]This investigation classed individuals as late bilinguals if they had an age of arrival in the L2 speaking country of over 16 and had lived in the L2 speaking country for longer than 15 years, which are the same criteria used in Makay et al. (2001). The definition of bilingualism is a highly complex issue which is beyond the scope of this study. For a more detailed outline see Gottardo & Grant (2008).

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Appendix 1

Phrase sets

Italian participants	**English participants**
1) Io ho un timbro	1) I have a teacher
2) Io ho un tino	2) My sister is tall
3) Devo dire gatto	3) I have a teapot
4) Io ho un tinto	4) I have a t-shirt
5) L'ho visto ieri	5) My dog is scruffy
6) Io ho un tipo	6) I have a teammate
7) Io ho un tiro	7) My sister is smaller than me
8) Devo dire dado	8) I have a teacup
9) Io ho un timo	9) My friend is younger than me
10) Io ho un timbro	10) I have a teaspoon
11) L'ho visto sabato	11) I have a teapot
12) Io ho un tipo	12) My friend is older than me
13) Devo dire gatto	13) I have a teacher
14) Io ho un timo	14) I have a teacup
15) L'ho visto lunedi	15) Your sister is tall
16) Io ho un tiro	16) I have a t-shirt
17) Devo dire famiglia	17) I have a housemate
18) Io ho un tinto	18) Your friend is younger than me
19) Devo dire tavolo	19) I have a teaspoon
20) Io ho un tino	20) Your sister is smaller than you